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UNITED STATES GEOLOGICAL SURVEY
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FOURTH ANNUAL REPORT

OF THE

RECLAMATION SERVICE

1904-5

F. H. NEWELL
Chief Engineer

WASHINGTON
GOVERNMENT PRINTING OFFICE
1906

2461
16-3

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LETTERS OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
WASHINGTON, *December 5, 1905.*

SIR: The act of Congress approved June 17, 1902, entitled "An act appropriating the receipts from the sale and disposal of public lands in certain States and Territories to the construction of irrigation works for the reclamation of arid lands," provides (section 2) as follows:

> That the Secretary of the Interior is hereby authorized and directed to make examinations and surveys for, and to locate and construct, as herein provided, irrigation works for the storage, diversion, and development of waters, including artesian wells, and to report to Congress at the beginning of each regular session as to the results of such examinations and surveys, giving estimates of cost of all contemplated works, the quantity and location of the lands which can be irrigated therefrom, and all facts relative to the practicability of each irrigation project; also the cost of works in process of construction, as well as of those which have been completed.

In compliance with the requirements of the statute, I have the honor to inclose herewith copy of a letter from the Director of the Geological Survey, dated the 29th ultimo, transmitting the report contemplated by the abovementioned section of the act of June 17, 1902.

Very respectfully,

E. A. HITCHCOCK,
Secretary.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., November 29, 1905.

SIR: I have the honor to transmit herewith a report of the work done and in progress under the reclamation act approved by the President June 17, 1902, together with other information essential to an understanding of the subject.

This report supplements and brings up to date the information given in the First Annual Report of the Reclamation Service, issued as House Document No. 79, Fifty-seventh Congress, second session; in the Second Annual Report of the Reclamation Service, issued as House Document No. 44, Fifty-eighth Congress, second session, and the Third Annual Report of the Reclamation Service, issued as House Document No. 28, Fifty-eighth Congress, third session. The latter report was first issued without illustrations, and later, owing to the demand for additional copies, a second edition was authorized to be printed, with illustrations. This fourth Annual Report is submitted with illustrations, consisting mainly of maps, plans, and diagrams, as it is found that there is a large demand for this information from landowners, investors, and public men, as well as from engineers.

The necessity of making a report to Congress at the beginning of each regular session results in a somewhat hasty preparation of material at the height of the field season, and at a time of the year when construction should be pushed most rapidly. If it were allowable to submit the report some months later it would be practicable to digest and arrange important data such as can be obtained only to advantage during the winter months when construction work is nearly at a standstill. Every effort, however, has been made to bring together the accompanying material in as good form as possible, and to give the latest figures or totals from the record books, as these are kept up day by day. The work carried on under the reclamation act is widely scattered, and hence it is impossible to follow the same orderly system that would prevail if the work were concentrated at one point, as, for example, in the water supply of a great city. The time taken in communication between the field and the Washington office is frequently so great that by the time estimates arrive and are checked over a new condition has arisen in the field. Thus, the figures given for any one day are necessarily subject to material change as new information arrives.

The reclamation act has been in effect for more than three years. During this period reconnaissance examinations and surveys have been carried on over a vast area and construction work has been begun at many widely scattered localities. An engineering corps has been organized and a large clerical and accounting force has been trained in the methods peculiar to Government affairs. A system of bookkeeping and cost keeping has been established and every effort made, first, to expedite the work; second, to insure economy; and third, to improve the system of accounting and cost keeping. It has not been practicable to follow what might be termed the logical order—that is, to lay out an ideal system first and then execute the work in accordance with this system; on the contrary, the demands for results have been so pressing that it has been necessary, first, to show results, and then, on the basis of the experience acquired, to organize and perfect the system.

Nearly all of the irrigation works are large and involve not merely engineering difficulties but an adjustment of intricate vested rights in lands and waters. The ground to be covered is rarely open, but is frequently covered with wrecks of various enterprises, these having little, if any, value beyond that derived from the opportunity of selling the wreckage at a good price to the Government. The work therefore requires not merely engineering skill but almost infinite patience and perseverance in overcoming obstacles resulting from the claims of individuals and corporations or from the operation of inadequate water laws. Notwithstanding these obstacles the work has been pushed forward energetically, and the results already obtained justify the belief that continued progress will be made along the lines indicated in this report.

Very respectfully,

CHAS. D. WALCOTT, *Director.*

The honorable SECRETARY OF THE INTERIOR.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
RECLAMATION SERVICE,
Washington, D. C., November 27, 1905.

SIR: In accordance with the provisions of section 2 of the reclamation act, I have the honor to transmit herewith the manuscript for the Fourth Annual Report of the Reclamation Service. This is similar in form to the first, second, and third annual reports and goes a little more into detail as regards expenditures and costs of the work.

Very respectfully.

F. H. NEWELL, *Chief Engineer.*

Hon. CHARLES D. WALCOTT,
Director of the United States Geological Survey.

FOURTH ANNUAL REPORT
OF THE
RECLAMATION SERVICE.

F. H. NEWELL, *Chief Engineer.*

GENERAL DISCUSSION.

The reclamation act (32 Stat. L., 388) has been in operation less than three years and a half. There have already been issued three annual reports of operations carried on under authority of that act, giving in detail the history of the work and the results accomplished. This report contains a statement of the operations during the greater part of the calendar year 1905.

RECLAMATION LAW.

For convenience of reference the full text of the reclamation act is here inserted. Much of the discussion concerning the operations under this act, and the effect of it on the future development of the West, has been had with little reference to the law itself, and it seems advisable frequently to call attention to the letter and the spirit of the act in order to prevent misconception of the objects and purposes of the Reclamation Service.

AN ACT appropriating the receipts from the sale and disposal of public lands in certain States and Territories to the construction of irrigation works for the reclamation of arid lands.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That all moneys received from the sale and disposal of public lands in Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington, and Wyoming, beginning with the fiscal year ending June thirtieth, nineteen hundred and one, including the surplus of fees and commissions in excess of allowances to registers and receivers, and excepting the five per centum of the proceeds of the sales of public lands in the above States set aside by law for educational and other purposes shall be, and the same are hereby, reserved, set aside, and appropriated as a special fund in the Treasury to be known as the "reclamation fund," to be used in the examination and survey for the construction and maintenance of irrigation works for the storage, diversion, and development of waters for the reclamation of arid and semiarid lands in the said States and Territories, and for the payment of all other expenditures provided for in this act: *Provided,* That in case the receipts from the sale and disposal of public lands other than those realized from the sale and disposal of lands referred to in this section are insufficient to meet the requirements for the support of agricultural colleges in the several States and Territories, under the act of August thirtieth, eighteen hundred and ninety, entitled "An act to apply a portion of the proceeds of the public lands to the more complete endowment and support of the colleges for the benefit of agricultural and mechanical arts, established under the provisions of an act of Congress approved July second, eighteen hundred and sixty-two," the deficiency, if any, in the sum necessary for the support of the said colleges shall be provided for from any moneys in the Treasury not otherwise appropriated.

SEC. 2. That the Secretary of the Interior is hereby authorized and directed to make examinations and surveys for, and to locate and construct, as herein provided, irrigation works for the storage, diversion, and development of waters, including artesian wells, and to report to Congress at the beginning of each regular session as to the results of such examinations and surveys, giving estimates of cost of all contemplated works, the quantity and location of the lands which can be irrigated therefrom, and all facts relative to the practicability of each irrigation project; also the cost of works in process of construction as well as those which have been completed.

SEC. 3. That the Secretary of the Interior shall, before giving the public notice provided for in section four of this act, withdraw from public entry the lands required for any irrigation works contemplated under the provisions of this act, and shall restore to public entry any of the lands so withdrawn when, in his judgment, such lands are not required for the purposes of this act; and the Secretary of the Interior is hereby authorized, at or immediately prior to the time of beginning the surveys for any contemplated irrigation works, to withdraw from entry, except under the homestead laws, any public lands believed to be susceptible of irrigation from said works: *Provided,* That all lands entered and entries made under the homestead laws within areas so withdrawn during such withdrawal shall be subject to all the provisions, limitations, charges, terms, and conditions of this act; that said surveys shall be prosecuted diligently to completion, and upon the completion thereof, and of the necessary maps, plans, and estimates of cost, the Secretary of the Interior shall determine whether or not said project is practicable and advisable, and if determined to be impracticable or unadvisable he shall thereupon restore said lands to entry; that public lands which it is proposed to irrigate by means of any contemplated works shall be subject to entry only under the provisions of the homestead laws in tracts not less than forty nor more than one hundred and sixty acres, and shall be subject to the limitations, charges, terms, and conditions herein provided: *Provided,* That the commutation provisions of the homestead laws shall not apply to entries made under this act.

SEC. 4. That upon the determination by the Secretary of the Interior that any irrigation project is practicable, he may cause to be let contracts for the construction of the same, in such portions or sections as it may be practicable to construct and complete as parts of the whole project, providing the necessary funds for such portions or sections are available in the reclamation fund, and thereupon he shall give public notice of the lands irrigable under such project, and limit of area per entry, which limit shall represent the acreage which, in the opinion of the Secretary, may be reasonably required for the support of a family upon the lands in question; also of the charges which shall be made per acre upon the said entries, and upon lands in private ownership which may be irrigated by the waters of the said irrigation project, and the number of annual installments, not exceeding ten, in which such charges shall be paid and the time when such payments shall commence. The said charges shall be determined with a view of returning to the reclamation fund the estimated cost of construction of the project, and shall be apportioned equitably: *Provided,* That in all construction work eight hours shall constitute a day's work, and no Mongolian labor shall be employed thereon.

SEC. 5. That the entryman upon lands to be irrigated by such works shall, in addition to compliance with the homestead laws, reclaim at least one-half of the total irrigable area of his entry for agricultural purposes, and before receiving patent for the lands covered by his entry shall pay to the Government the charges apportioned against such tract, as provided in section four. No right to the use of water for land in private ownership shall be sold for a tract exceeding one hundred and sixty acres to any one landowner, and no such sale shall be made to any landowner unless he be an actual bona fide resident on such land, or occupant thereof residing in the neighborhood of said land, and no such right shall permanently attach until all payments therefor are made. The annual installments shall be paid to the receiver of the local land office of the district in which the land is situated, and a failure to make any two payments when due shall render the entry subject to cancellation, with the forfeiture of all rights under this act, as well as of any moneys already paid thereon. All moneys received from the above sources shall be paid into the reclamation fund. Registers and receivers shall be allowed the usual commissions on all moneys paid for lands entered under this act.

SEC. 6. That the Secretary of the Interior is hereby authorized and directed to use the reclamation fund for the operation and maintenance of all reservoirs and irrigation works constructed under the provisions of this act: *Provided,* That when the payments required by this act are made for the major portion of the lands irrigated from the waters of any of the works herein provided for, then the management and operation of such irrigation works shall pass to the owners of the lands irrigated thereby, to be maintained at their expense under such form of organization and under such rules and regulations as may be acceptable to the Secretary of the Interior: *Provided*, That the title to and the management and operation of the reservoirs and the works necessary for their protection and operation shall remain in the Government until otherwise provided by Congress.

SEC. 7. That where in carrying out the provisions of this act it becomes necessary to acquire any rights or property, the Secretary of the Interior is hereby authorized to acquire the same for the United States by purchase or by condemnation under judicial process, and to pay from the reclamation fund the sums which may be needed for that purpose, and it shall be the duty of the Attorney-General of the United States upon every application of the Secretary of the Interior under this act to cause proceedings to be commenced for condemnation within thirty days from the receipt of the application at the Department of Justice.

SEC. 8. That nothing in this act shall be construed as affecting or intended to affect or to in any way interfere with the laws of any State or Territory relating to the control, appropriation, use, or distribution of water used in irrigation, or any vested right acquired thereunder, and the Secretary of the Interior, in carrying out the provisions of this act, shall proceed in conformity with such laws, and nothing herein shall in any way affect any right of any State or of the Federal Government or of any landowner, appropriator, or user of water in, to, or from any interstate stream or the waters thereof: *Provided*, That the right to the use of water acquired under the provisions of this act shall be appurtenant to the land irrigated, and beneficial use shall be the basis, the measure, and the limit of the right.

SEC. 9. That it is hereby declared to be the duty of the Secretary of the Interior in carrying out the provisions of this act, so far as the same may be practicable and subject to the existence of feasible irrigation projects, to expend the major portion of the funds arising from the sale of public lands within each State and Territory hereinbefore named for the benefit of arid and semiarid lands within the limits of such State or Territory: *Provided*, That the Secretary may temporarily use such portion of said funds for the benefit of arid or semiarid lands in any particular State or Territory hereinbefore named as he may deem advisable, but when so used the excess shall be restored to the fund as soon as practicable, to the end that ultimately, and in any event, within each ten-year period after the passage of this act, the expenditures for the benefit of the said States and Territories shall be equalized according to the proportions and subject to the conditions as to practicability and feasibility aforesaid.

SEC. 10. That the Secretary of the Interior is hereby authorized to perform any and all acts and to make such rules and regulations as may be necessary and proper for the purpose of carrying the provisions of this act into full force and effect.

Approved, June 17, 1902.

DETAILS OF THE LAW.

The law has been in operation less than three and one-half years, but during that time a great many questions have arisen concerning details which could not have been anticipated in the law itself. Most of these have been satisfactorily settled, and good precedents have been established on points where discretion has been left to executive officers.

FUNDS FOR RECLAMATION.

The fund set aside by the act, as shown by section 1, is derived from the sale and disposal of public lands in thirteen States and three Territories.

EXAMINATIONS AND SURVEYS.

Section 2 of the act directs the Secretary of the Interior to make examinations and surveys and to construct irrigation works. In order to carry out these operations there has been gradually created what is known as the "Reclamation Service," for which competent men have been selected through civil-service examination. The organization of this corps of engineers has been a matter of evolution, necessitated by the circumstances, attempt being made to secure the largest efficiency irrespective of other considerations.

Section 2 also directs that a report be made giving the results of examinations and surveys, estimates of cost, and all other facts relative to the practicability of each irrigation project. These matters of cost and of practicability are fundamental, and great care is taken to check the preliminary estimates against the facts obtained by actual experience as the work progresses.

WITHDRAWAL OF LANDS.

Section 3 provides for making temporary or permanent withdrawals of lands for survey or for the construction of works. In each area under examination bodies of land have been withdrawn for one or the other purpose. Two forms of withdrawal are specified; the first absolute, the second subject to limitations. Under the first form of withdrawal the lands indicated are withheld by the Government from all forms of entry and settlement. In this manner areas needed for various kinds of structures or works are set aside and can not be filed upon nor can title to them be acquired under any of the land laws.

Under the second form of withdrawal the lands are subject to entry under the homestead laws without commutation provisions. Considerable tracts containing irrigable lands are thus set aside, and these may be entered by settlers who have not used their homestead rights. In making entries, however, the homesteader becomes subject to various limitations and charges, and the size of his entry may be cut down from 160 to 40 acres. This condition is giving rise to more or less confusion from the fact that under existing law and the decisions of the Department the public lands which may be irrigated are first taken up in tracts of 160 acres, and later, when these are cut down to 80 acres, or even 40 acres, there is uncertainty or controversy regarding the portion of the 160 acres which shall be allotted to the entryman. Many of these controversies could be avoided if it were possible to amend the law so as to limit the entry to 40 or 80 acres at the time when it was known that such limitation should be put upon the land. As the matter now stands, this announcement can not be properly made until the contracts for the construction of work have been let.

As a rule all of the irrigable public land which is being surveyed under each project is entered at once in 160-acre tracts. It is generally known in advance that the farm unit will be reduced, but the entrymen prefer to enter all of the land possible and take the chances that the necessary relinquishment may be in some manner profitable to themselves.

CONSTRUCTION AND CHARGES.

Section 4 provides for the letting of contracts for construction work, and authorizes the Secretary of the Interior to give public notice of the lands irrigable and the limit of area per entry. This limit is intended to represent the acreage which, in the opinion of the Secretary, may be reasonably required for the support of a family upon the lands. It has been decided that this limit shall be in multiples of 40, excepting in the case of irregular lots shown in the public-land surveys. The Secretary, in short, must, after considering the character of the land, designate certain farm units, these being 40 acres, 80 acres, 120 acres, or 160 acres in extent. The separation of any particular tract of land into farm units requires a full knowledge of the soil, its capacity to produce crops, and its liability to injury by becoming swampy or alkaline. As is well known, much of the land under an irrigation system tends to deteriorate in character and become incapable of supporting a family unless great care is used in providing drainage or in applying water to the lands in the vicinity.

One of the most important provisions of the law is contained in this section, namely, that requiring that each project undertaken shall repay the estimated cost of its construction. This is an effective safeguard against undertaking visionary or unprofitable projects, and puts the operations under the law on a sound basis. The fact that each project must return its cost cuts out of consideration at once a large number of the dubious or chimerical schemes that are continually being exploited, and removes the temptation to try expensive experiments.

Section 5 defines how payment shall be made, and introduces the matter of reclamation of lands in private ownership. At the time the law was under consideration it was supposed that it would be applicable mainly to public lands, but results of surveys and examinations of definite projects are beginning to show that the amount of public land that may be reclaimed is not so large as was expected, and that the lands in private ownership are frequently more important or more valuable than the public lands. The great and indispensable safeguard in this connection is the restriction of ownership of these lands to 160 acres. By carefully guarding this provision and insisting upon compliance with the letter and spirit of the law it will be possible to bring about the subdivision of private lands into relatively small holdings and to establish and maintain intensive cultivation of the soil.

OPERATION AND MAINTENANCE OF WORKS.

Section 6 gives authority for operating and maintaining the works, and provides for passing the management to the owners of the land when the major portion of the payments have been made. In short, after the works are in successful operation and have been partly paid for, the management passes into the hands of the water users. It has been found essential to consider very carefully the organization of the water users, particularly where a large part of the lands are already in private ownership, and a more complete discussion of the many problems encountered will be found on later pages.

CONDEMNATION PROCEEDINGS.

Section 7 gives the Secretary of the Interior authority to purchase necessary property or to obtain it by condemnation proceedings. Every reasonable effort is being made to avoid condemnation proceedings and to acquire needed properties by agreement.

STATE LAWS.

Section 8 bears upon State laws and vested rights. It brings about the need of a more or less complete study of existing systems of water appropriation and necessitates taking up with State officials and legislators many details of State laws or proposed amendments. It is very important to secure as nearly a uniform system of laws in the various States as may be consistent with the different physical conditions, and it is believed that as time goes on the State laws will be brought into greater harmony with one another and with the necessities of irrigation development.

DISTRIBUTION OF EXPENDITURE.

Section 9 provides that the funds derived from the sale of public lands in each State and Territory shall be divided into two portions—a major and minor portion—and that the major portion shall be expended within such State or Territory. For convenience it has been assumed that the major portion is 51 per cent of the fund. This may be termed the restricted portion, since its expenditure is restricted to the State in which it is paid.

RULES AND REGULATIONS.

Section 10 gives general authority to the Secretary to perform necessary acts and make essential regulations, the regulations being promulgated from time to time as occasion requires, in order that they may be adapted to conditions found in actual practice. The law leaves executive discretion a wide range, and it has not been considered desirable to attempt to anticipate the conditions which might arise, but rather to meet them as they come and to promulgate rules and regulations on the basis of experience.

DECISIONS OF THE SECRETARY OF THE INTERIOR.

The following is a brief statement of decisions of general interest relating to the reclamation act which have been made by the Secretary of the Interior:

WITHDRAWAL OF LANDS.

February 11, 1903.—Two different forms of withdrawal are authorized by section 3 of the reclamation act. The first form provides for withdrawal from public entry of lands required for irrigation works, under which no entries of any kind can be allowed. The second form of withdrawal leaves the land open to homestead entry under the provisions, limitations, charges, terms, and conditions of the act, and is intended to apply to lands irrigable from the works constructed. (32 L. D., 6.)

September 5, 1903.—There is no authority to make such executive withdrawal of public lands in a State as will reserve the waters of a stream flowing over the same from appropriation under the laws of the State, or will in any manner interfere with its laws relating to the control, appropriation, use, or distribution of water. (32 L. D., 254.)

January 13, 1904.—Withdrawals under the reclamation act operate to withdraw from other disposition all lands within the designated limits to which a right has not vested. (32 L. D., 387.)

June 28, 1904.—Withdrawal under the second form precludes any other form or mode of entry or appropriation of the land than homestead. Land so withdrawn can not be taken up in lieu of land relinquished to the United States in the forest reserve. (33 L. D., 360.)

July 12, 1904.—The first form of withdrawal, under which no entries of any kind can be allowed, may be used in all preliminary withdrawals. (33 L. D., 104.)

February 18, 1905.—No authority is granted by the reclamation act for the withdrawal of lands for reservoir sites for storing water to be used for domestic purposes. (33 L. D., 415.)

April 20, 1905.—Upon the cancellation of a homestead entry a subsequent withdrawal becomes effective as to the lands covered thereby without further order. (33 L. D., 520.)

October 12, 1905.—The Secretary of the Interior, after full consideration of previous rulings, issued the following instructions as to the procedure to be followed thereafter in making withdrawals under the reclamation act:

1. When a site has been selected with a view to making an examination and survey for the purpose of determining whether the construction of an irrigation project upon such a site is practicable and advisable, a withdrawal will immediately be made of all lands believed to be susceptible of irrigation from such contemplated works in accordance with the second form of withdrawal provided for by the third section of the act of June 17, 1902. At the same time a preliminary withdrawal will be made of lands that may be needed for use in the construction and operation of the works which will

reserve such lands from entry of every character, but will not affect entries previously made.

2. As soon as it shall be determined that the project is practicable and advisable and the construction of the same is approved and authorized by the Secretary of the Interior, a withdrawal will be made of all public lands shown by the examination and survey to be required for use in the construction and operation of the works, and all persons who may have made entry of such lands within such withdrawal prior to the preliminary withdrawal and who have not acquired a vested right thereto will be notified of the appropriation of their lands for irrigation purposes and that their entry will be canceled and their improvements paid for by the Government, as provided for by the eighth and ninth sections of the circular of June 6, 1905 (33 L. D., 607), unless sufficient cause is shown within sixty days from the date of such notice.

RESTORATION OF LANDS.

September 14, 1904.—In an opinion by the Assistant Attorney-General, approved by the Acting Secretary of the Interior, it is held that when an order of withdrawal is revoked the time for making entries may be fixed at some date in the future, leaving the lands subject to settlement from the date of the order of the revocation. This permits a right to attach to such lands, as the result of settlement, in advance of the possible filing of an entry for the same land by one who has not settled thereon. (33 L. D., 206.)

ENTRIES AND SELECTIONS.

November 17, 1902.—There is no authority for specifying any limitation in the area of homestead entries, under the reclamation act, in advance of a definite determination to enter upon the necessary construction for the project in question, and the issuance of a public notice provided for in section 4. This matter was further considered and a similar decision reached by the Secretary on February 11, 1903.

July 6, 1903.—Whenever final proof is offered on any desert-land entry for lands within the limits of the withdrawals for the Reclamation Service, an inspection will be made by the engineers of the Reclamation Service to determine whether the entryman has complied with the desert-land laws and regulations.

August 21, 1903.—The Reclamation Service is authorized to classify and combine the different subdivisions within lands withdrawn for irrigation under the reclamation act so as to make practically homestead segregations of the entire territory under one project, specifying the particular legal subdivisions that shall constitute each entry as to all public land included in the withdrawal. (32 L. D., 327).

January 13, 1904.—A withdrawal under the reclamation act becomes operative upon the lands covered by timber and stone applications when no payment has been made, and terminates the contingent right of the applicant.

In cases where valid locations of mining claims were made prior to the date of withdrawal, and the mining laws duly complied with in good faith by the locators or their grantees, the possessory rights so obtained by such locations and duly maintained will be respected by the Government. The requisites of a valid location are (1) discovery, (2) the marking of the location on the ground so that its boundaries may be readily traced, and (3) compliance with local regulations. (32 L. D., 387.)

January 14, 1904.—By a successful contest against a desert-land entry the contestant does not acquire such a preference right of entry as will, prior to its exercise, except the land from the operation of a withdrawal for irrigation purposes made under the provisions of the act of June 17, 1902. (32 L. D., 396.)

February 17, 1904.—In a decision of this date (32 L. D., 456) certain rules are laid down with regard to the acceptance of final proof in desert-land entries made within the areas withdrawn under the reclamation act, and by circular letter of February 23, 1904, an extract of this decision was communicated to the engineers in charge of projects for their guidance in reporting upon such entries. The extract reads as follows:

> Proof which shows that because of irrigation there is on the land "a marked increase in the growth of grass" or that "grass sufficient to support stock has been produced on all the land" will not be accepted as showing a compliance with that provision of the amendatory act of 1891 (26 Stat., 1905), "that proof be further required of the cultivation of one-eighth of the land." Actual tillage must, as a rule, be shown. If, however, it be shown—and it must be made conclusively so to appear—that because of climatic conditions crops other than grass can not be successfully produced, or that actual tillage of the soil will destroy or injure its productive qualities, the actual production of a crop of hay of merchantable value, as a result of actual irrigation, may be accepted as sufficient compliance with the requirement as to cultivation.
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> That the entryman has an absolute right to sufficient water to successfully irrigate the land, that the system of ditches to conduct the water to and distribute it over the land is adequate for those purposes, and that the land has been actually irrigated for a sufficient period of time to demonstrate the sufficiency of the water supply, and the effectiveness of the system, are essential facts which must in all cases be clearly established by the proofs.

March 30, 1904.—Lands withdrawn from entry under the second form of withdrawal (page 24) are not subject to desert-entry, even when the applicant has commenced a system of irrigation. (32 L. D., 536.)

April 14, 1904.—Lands withdrawn from "settlement, entry, or other form of disposal under the public-land laws, except the homestead laws," in accordance with the provisions of the act of June 17, 1902, are not, during the continuance of such withdrawal, subject to disposal under the coal-land laws, where no rights thereto were initiated under such laws prior to the order of withdrawal. (32 L. D., 560.)

May 17, 1904.—Persons making homestead entry of lands within the irrigable area of any project commenced or contemplated under the provisions of the act of June 17, 1902, will be required to comply fully with the requirements of the homestead law as to residence, cultivation, and improvement, and failure to supply water from such works in time for use upon the land entered will not justify a failure to comply with the law and to make proof thereof within the time required by the statute. (32 L. D., 633.)

September 20, 1904.—There is no authority for granting a leave of absence to a homesteader who made entry under the provisions of the act of June 17, 1902, on the ground that he can raise no crops on the land prior to the completion of the project proposed to be constructed under said act. (32 L. D., 257.)

December 9, 1904.—A selection in lieu of lands in a forest reserve filed under the act of January 4, 1897, without requisite proofs at date of withdrawal under the reclamation act will not except the land from the effect of such withdrawal. (33 L. D., 350.)

April 20, 1905.—Lands withdrawn under the second form are not subject to soldiers' additional entry under sec. 2306, R. S. (3 L. D., 525.)

June 28, 1905.—Lands withdrawn from entry, except under the homestead laws, are not subject to selection under the exchange provision of the act of June 4, 1897, in lieu of lands relinquished to the United States in forest reserves. (33 L. D., 360.)

WATER RIGHTS.

March 20, 1903.—The Director of the Geological Survey is authorized to designate suitable persons to file notices of water appropriation for the projects of the Reclamation Service, in the name of and on behalf of the Secretary of the Interior, in pursuance of the provisions of section 8 of the reclamation act.

September 5, 1903.—There is no authority to make such Executive withdrawal of public lands in a State as will reserve the waters of a stream flowing over the same from appropriation under the laws of the State or will in any manner interfere with its laws relating to the control, appropriation, use, or distribution of the water. (32 L. D., 254.)

RIGHTS OF WAY.

May 8, 1904.—No rights are acquired by an application for a right of way under the act of February 15, 1901, prior to the approval thereof by the Secretary of the Interior. (32 L. D., 597.)

No such right is acquired by virtue of an application for right of way for a railroad under the act of March 3, 1875, before the approval thereof and prior to the construction of the road, as will prevent the Secretary from withdrawing the lands covered thereby for use as a reservoir site under the provisions of the act of June 17, 1902.

June 4, 1903.—The act of August 30, 1890, with regard to reservations for rights of way, does not apply to (1) land taken under the indemnity clause of railroad land grants which has actually been selected; nor (2) to various school land grants to States or Territories; nor (3) to indemnity school selections; nor (4) to educational and other grants to States and Territories, where selections have been made; nor (5) to special grants by acts of Congress. (32 L. D., 147.)

June 17, 1904.—Where a right of way for a reservoir site has been granted under the act of March 3, 1891, which provides that entries subsequent to such grant shall be subject thereto, the United States, in purchasing the rights of such grantee, does not succeed to the superior rights granted by said act as to entries made subsequent to such grant; and the right to flood and appropriate lands and improvements under such subsequent entries must be acquired by the United States by agreement or by condemnation proceedings.

May 18, 1905.—For the purpose of carrying out the provisions of the act of June 17, 1902, the Government may avail itself of the privileges conferred by the act of March 3, 1891, granting right of way through the public lands for constructing ditches and reservoirs for irrigation purposes to the same extent that individuals, corporations, or associations of individuals may exercise such privileges, and subject to the same conditions and limitations. (33 L. D., 563.)

RIGHT OF WAY APPLICATIONS.

July 14, 1902.—The Commissioner of the General Land Office was instructed to submit to the Director of the Geological Survey, for his consideration and report, all applications for rights of way over the lands withdrawn for the uses of the Reclamation Service.

September 18, 1902.—The above instructions were extended to cover rights of way applied for within the limits of forest reserves.

June 23, 1903.—The Commissioner of the General Land Office was instructed to submit to the Director of the Geological Survey all the applications received for rights of way for canals or reservoirs in any of the States or Territories subject to the operations of the reclamation act.

SURVEYS.

May 9, 1903.—As the land which it is proposed to reclaim under some of the projects now being studied has not been subdivided in accordance with the public-land surveys, and as such subdivisions will be necessary in order to make proper descriptions for the disposal of the same, the Secretary decided that the necessary public-land surveys could be ordered whenever they were found advisable.

July 14, 1903.—The Director was authorized to instruct the engineers and topographers of the Reclamation Service to retrace and re-mark the public-land lines within the areas under survey with a view to their reclamation.

ARTESIAN WELLS.

March 3, 1903.—The reclamation fund can not be used for drilling artesian wells for exploration. Such wells may be paid for from the reclamation fund only in cases when there is sufficient knowledge in advance to make it probable that water will be obtained from them in sufficient quantities for the irrigation of lands, with the probability that the cost will be returned to the reclamation fund. (32 L. D., 278.)

LAND AND PROPERTY PURCHASES.

March 20, 1903.—Whenever the Director is authorized by the Department to enter on negotiations looking to the acquisition by the United States of rights or property, or both, he will designate such persons as he thinks proper to carry on such negotiations.

April 28, 1903.—The expenses of procuring abstracts of title to lands or rights are payable from the reclamation fund, provided the lands or rights are to be purchased and not condemned.

January 28, 1904.—When land the acquisition of which is necessary is not needed at once and can be purchased for a less price if the vendor is allowed to retain possession until the land is needed, an arrangement to that effect may be entered into. But after purchase and possession by the United States such lands can not be leased.

March 24, 1904.—The Attorney-General instructed the United States attorney at Tucson, Ariz., to cooperate with the officers of the Reclamation Service in securing valid titles to lands sought to be purchased. These instructions serve as a precedent for obtaining similar cooperation in other districts.

April 8, 1904.—Where the purchase of real property is contemplated, the title thereto will be passed upon by the assistant attorney-general for the Department of the Interior.

February 6, 1905.—Where an irrigation system already constructed and in operation may be utilized in connection with a greater system to be constructed, its purchase for such purpose comes within the purview of the reclamation act. The reclamation fund can be used only for the purchase of lands necessary for the construction and operation of irrigation works within the territorial limits of the United States. (33 L. D., 391.)

October 12, 1905.—Settlers upon lands within the limits of a withdrawal made under the terms of the reclamation act can not be compensated for improvements when the land is taken for construction purposes unless they have acquired a right as qualified settlers under the public land laws at the date of the withdrawal.

LANDS IN PRIVATE OWNERSHIP.

May 21, 1904.—Where lands are in private ownership in blocks of more than 160 acres the excess may be conveyed to members of the owner's family, provided the transfer is bona fide and the requirements of the reclamation act as to residence are complied with. (32 L. D., 647.)

August 30, 1904.—In regard to the disposition under reclamation projects of lands in private ownership held in tracts of more than 160 acres by any one person, it was held that the views of the Department as to the necessities of the case would be satisfied by any agreement drawn upon the lines suggested in the forms adopted by the Uncompahgre Valley Water Users' Association or the Yuma County Water Users' Association. These forms provide for vesting in these associations the title to the excess of lands owned in blocks of more than 160 acres and authorize them to sell the lands in case of the failure of the owner to dispose of them to persons qualified to apply for water rights under the reclamation act by the time the Government is ready to furnish the water. (33 L. D., 202.)

OPTIONS.

April 28, 1903.—Payment of a sum of money for an option for a right of way, water right, or land needed for the reclamation work would not be a proper expenditure from the reclamation fund.

EXCHANGE OF LANDS.

February 20, 1904.—The Secretary has no authority to permit the owner of lands that are needed for a reservoir to be constructed under the terms of the reclamation act to select other lands of the same area within the district that may be made susceptible of irrigation from the proposed reservoir in exchange for the lands so needed for reservoir purposes. (32 L. D., 459.)

PRINTING.

October 28, 1903.—In view of the opinion of the Assistant Comptroller, dated October 21, 1903, that the Secretary of the Interior is authorized, under the provisions of section 10 of the reclamation act, to prescribe, by rule and regulation, the manner in which printing may be done by engineers in the field, the Secretary authorized the Director to have the requisite printing done locally, when necessary, in the prosecution of reclamation work, and directed that it be paid for from the reclamation fund.

September 22, 1905.—The Director of the Geological Survey has authority to print specifications for the Reclamation Service as soon as they are received, at the lowest obtainable price for prompt delivery, and to pay therefor from the reclamation fund.

TRESPASSERS.

February 25, 1904.—Withdrawals under the first form of withdrawal (p. 24) are absolute, and the Department may remove persons from such lands as trespassers.

INDIAN RESERVATIONS.

February 9, 1904.—As a rule ceded Indian lands are subject to disposition under certain specific acts mentioned in the treaty or the act of Congress providing for the cession, and hence would not be subject to withdrawal under the provisions of the reclamation act. Specific decisions will be made on each case.

ABANDONED MILITARY RESERVATION.

July 20, 1904.—The Secretary of the Interior is without authority to segregate lands in abandoned military reservations for use as reservoir sites in connection with an irrigation project under the act of June 17, 1902. (33 L. D., 130.)

NOTICE.

August 5, 1905,—In giving public notice of the lands to be irrigated, of the adjustment of entries to the farm unit determined upon, and of the estimated payments, the register and receiver of the local land office are required to cause such notice to be given by posting in the local land office, by publication, and by mailing special notice by registered mail to every person who may have made entry during the period of withdrawal, requiring him to adjust his entry within sixty days[a] from the receipt of notice. (33 L. D., 191.)

WATER USERS' ASSOCIATIONS.

August 30, 1905.—The United States is not to be a party to a contract between water users' associations and the owners of lands lying within the irrigable area of a project; its only interest in the agreement or benefit it may derive therefrom is in the subdivision of large holdings in tracts not exceeding 160 acres and the transfer of the excessive lands to individuals who will reside thereon and bring them within the provisions of the irrigation act, and in the mutual agreement to be secured thereby between water users throughout the irrigable area upon the use and distribution of the water and the subordination of whatever rights they may have theretofore acquired to the provisions and conditions of the reclamation act. Agreements drawn upon such lines, providing a method of sale for excess lands conforming to the local law governing judicial sales, are satisfactory to the Department. (33 L. D., 202.)

FOREST RESERVES AND NATIONAL PARK.

December 30, 1904.—Lands in forest reserves and in the Yosemite National Park may be appropriated and used for irrigation works to be constructed under the reclamation act. (33 L. D., 389.)

RECLAMATION FUND.

February 6, 1905.—The authority of the Secretary of the Interior respecting the use of the reclamation fund as defined and limited by the act is to make preliminary investigation to determine the feasibility of any contemplated irrigation project, to construct and operate reservoirs and irrigation works, and to acquire rights or property necessary for these purposes. (33 L. D., 391.)

NAVIGABLE STREAMS.

February 6, 1905.—Congress has control over navigable streams and the waters thereof, and no claim based upon appropriation of such waters for irrigation purposes, made without the sanction of Congress, should be recognized by the Secretary of the Interior as valid. (33 L. D., 391.)

LOCATION OF RECLAMATION PROJECTS, FORESTED AREAS, AND OPEN RANGE.

The location of the principal reclamation projects is shown on Pl. I, which gives the outlines of the States and also of the areas now included within the forest reserves. These have been created largely with a view to conserve the water supply for the benefit of irrigation, and their position with reference to the irrigation projects is of importance particularly with reference to the expanse of wooded or forested areas, from which come the principal parts of water supply, and from which are derived the fuel and the fence posts, poles, and

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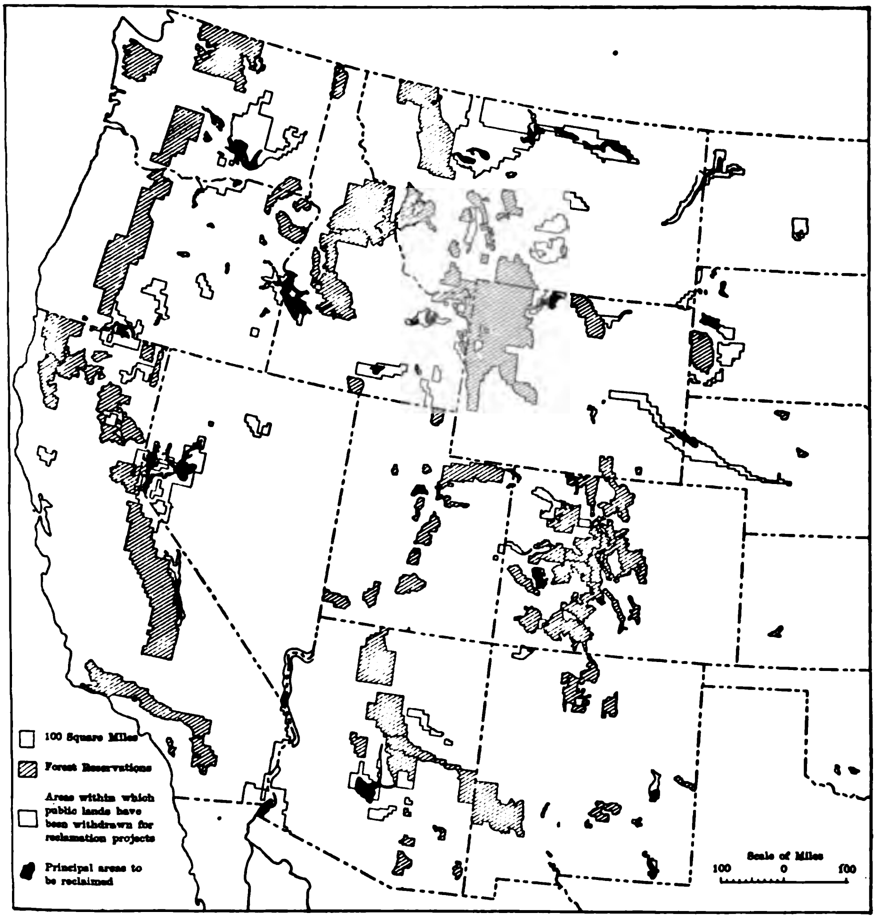
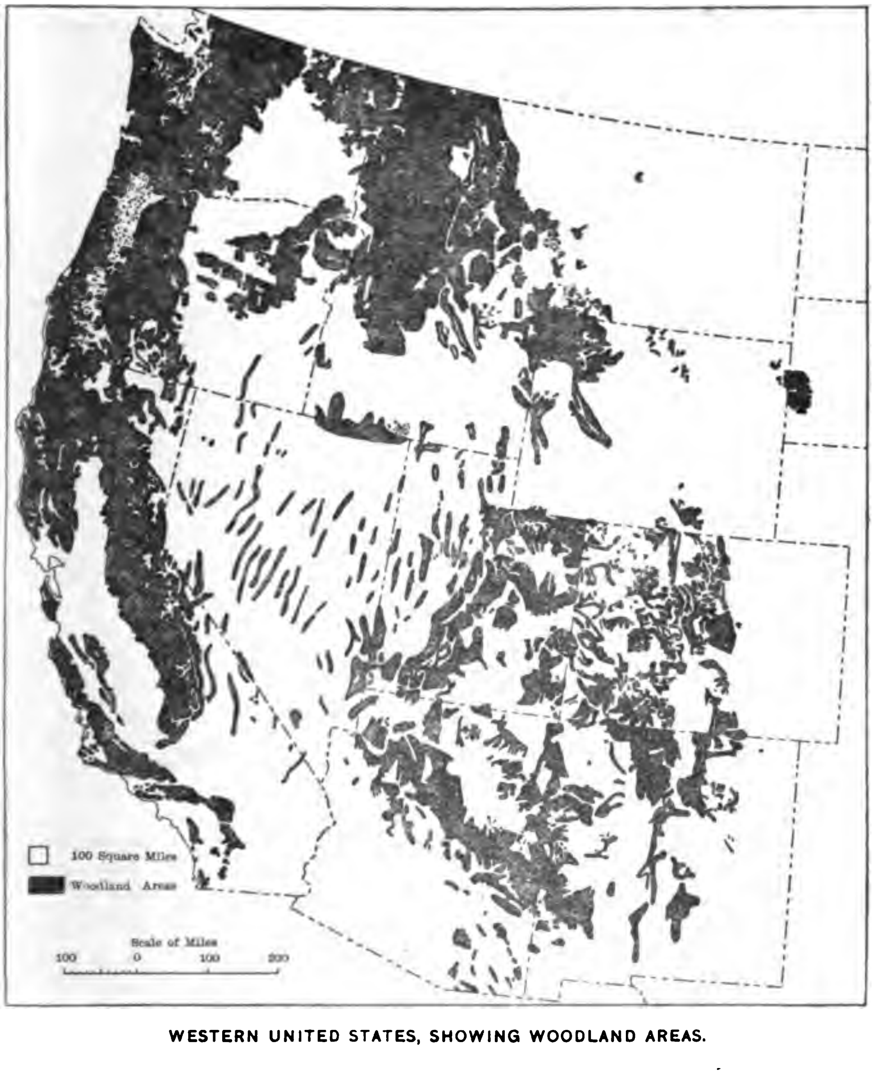
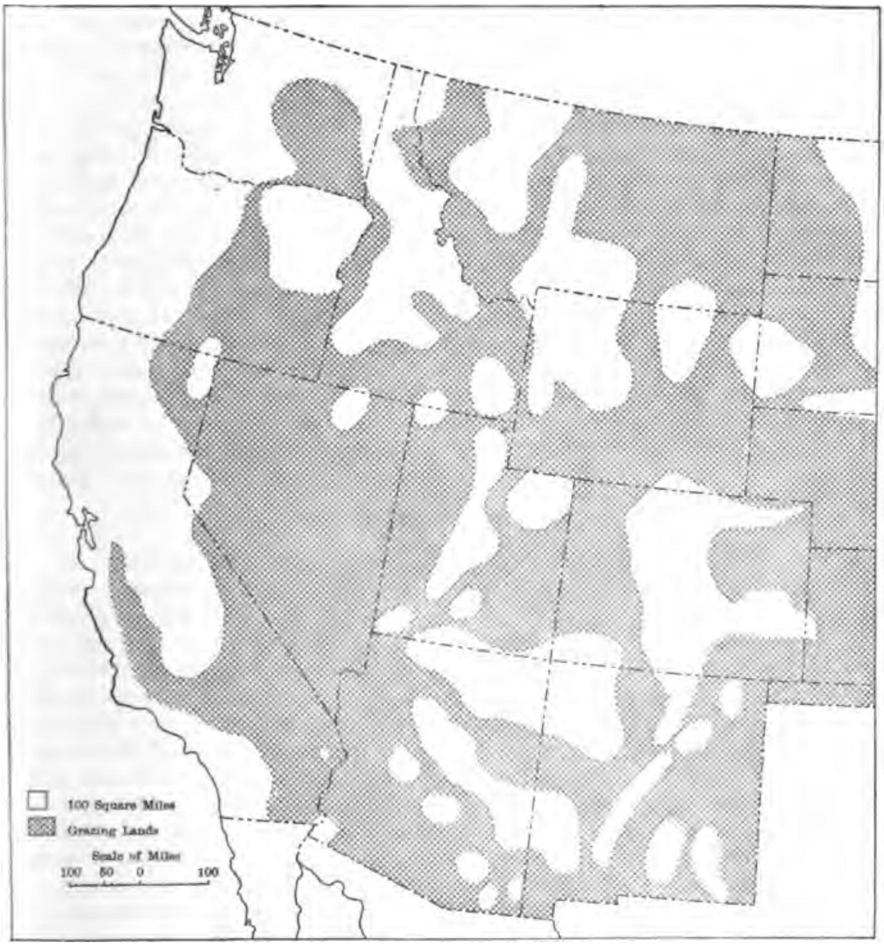
[a] August 18, 1904 (33 L. D., 158), thirty days allowed.


100 Square Miles
Forest Reservations
Areas within which public lands have been withdrawn for reclamation projects
Principal areas to be reclaimed
Scale of Miles
100 0 100

WESTERN UNITED STATES, SHOWING FOREST RESERVES AND RECLAMATION PROJECTS.



WESTERN UNITED STATES, SHOWING WOODLAND AREAS.



WESTERN UNITED STATES, SHOWING OPEN-RANGE AREAS.

lumber necessary to the success of the settler. The location of these forests or wooded areas is shown on Pl. II, which gives the outline of the western States and Territories and shows the forested areas.

The location of the principal areas to be irrigated under the terms of the reclamation act is shown by the black spots on Pl. I. These are within extensive areas, whose outlines are shown on the map. These boundaries indicate the positions of the townships within which public lands have been temporarily segregated pending survey and examination. Most of this land has already passed out of the control of the Government, but it was deemed wise at the outset to make reservation of considerable areas, in order to allow latitude in final selection of the lands that might be reclaimed.

Much of the success of the settler upon lands irrigated under the terms of the reclamation act is dependent upon the use of the grazing land. The vast extent of open grazing country is shown on Pl. III by the cross-hatched area. Although this country is theoretically open to all citizens and can be utilized for grazing, yet practically it is to a large extent subdivided and held by various stockmen, who control the water supply and in one way or another render it difficult or impossible for the newcomer to find subsistence for his animals. One of the problems yet unsettled is that of securing to the settler under the terms of the reclamation act the use of the surrounding grazing land until such time at least as he is able to establish himself. He must at first, while breaking up the ground, subduing the soil, setting out trees, and getting his land in form for agriculture, have some free range where his animals can obtain subsistence. Consideration for the general welfare demands that herds of cattle or bands of sheep owned by nonresident citizens should not be permitted to destroy the grazing in the immediate vicinity of the small farm of the settler under the irrigation act.

PROGRESS OF WORK.

The projects which appear to be most meritorious and which present the least obstacles to early achievement have been first selected, and work has been begun on these. At the same time in performing work in one State the interests of other States have not been neglected, but it has been found that the greatest obstacles, both from the engineering and the human standpoint, are encountered in States from which the largest funds have been derived. This is because these States are not truly arid, for dry farming is now successfully carried on in them, and most of the farmers do not desire to change their methods and take up the more laborious work of intensive cultivation under irrigation. As a result, there have been great obstacles to overcome in these States, and in some it has been necessary to leave the restricted fund as an amount which may be expended in future, when feasible plans can be made.

There are two distinct ways in which the reclamation fund may be expended—(1) construction may be undertaken only when the funds in the Treasury are ample to complete the entire work, which may extend over several years; (2) work on each project may be started if funds will probably be available before the work is finished in all of its parts.

Under the first plan it would be necessary to keep in the Treasury for several years all the money that would be needed for construction in the future, and to work only on such projects as could be completed by the fund actually in hand.

Under the second plan, work could be started at all points at once, contracts being made, however, only for parts which can be completed as a whole, and for which there are ample funds in the Treasury. By this plan the works would be completed several years earlier than by the first plan, and a great part of the reclamation fund would not lie idle indefinitely.

Work has been pushed energetically on all projects where construction has been begun. There have been some delays, due to floods and other unforeseen events, but on the whole the contractors have all pushed their work, and most of them will probably complete it within the required time.

The table below shows the construction work that has been accomplished on all the projects:

Work completed on reclamation projects.

Main canals constructed	miles	77
Distributing canals constructed	do	54
Irrigation ditches constructed	do	186
Telephone lines completed	do	250
Tunnel driven	do	3½
Roads constructed	do	126
Office and buildings		50
Cement mill		1
Bridges built		147
Excavation accomplished	cubic yards	9, 350, 000
Concreting accomplished	do	70, 000
Puddling done	do	4, 500
Riprap	do	12, 000
Lumber purchased	feet B. M.	1, 750, 000
Lumber sawed	do	2, 880, 000
Sheet piling driven	linear feet	15, 000
Bearing piles driven	do	10, 000
Railroad iron used	pounds	130, 000
Structural steel used	do	250, 000
Paving	square feet	190, 000
Cement purchased	barrels	78, 000
Cement manufactured	do	15, 000

The stage of the work on each project is given below:

Salt River project, Arizona.—On this project the cement mill, telephone system, and temporary power plant have been completed and are now in operation. The power canal is about 98 per cent finished and will be completed in a short time. The contractors for the Roosevelt dam have been assembling their equipment and are ready to push operations.

Yuma project, California-Arizona.—About 2½ per cent of the Laguna dam is completed and about 9 per cent of the dike system.

Uncompahgre Valley project, Colorado.—The telephone system on the Uncompahgre Valley project has been completed and is in operation. Divisions 1 to 10 of the South canal are finished, and some work has been done on divisions 11 to 20. The entire South canal may be regarded as about 15 per cent completed. After the contractors had completed about 2 per cent of the Gunnison tunnel they gave up the contract and the work has since been carried on under force account. About 15 per cent of the tunnel is completed.

Minidoka project, Idaho.—The work on the dam, spillway, and canal may be considered as half finished, and about 21 per cent of the work on the distributing canal has been done.

Huntley project, Montana.—There has been some delay in the work on this project, due to the refusal of bidders to execute the contracts. It is believed that everything is now arranged and that construction will proceed rapidly. About 1 per cent of the structures is completed.

Lower Yellowstone project, Montana-North Dakota.—The telephone system is about 40 per cent completed, and about 5 per cent of the structures and 4 per cent of the canals are finished.

North Platte project, Nebraska-Wyoming.—The Pathfinder tunnel is complete, and about 72 per cent of the Interstate canal remains to be done. The contractor is beginning work on the Pathfinder dam.

Truckee-Carson project, Nevada.—The main canal and the distributing canals on the Truckee-Carson project are now complete and water has been turned into them. The ditches are about 95 per cent finished. Little has been done on the regulating works at Lake Tahoe, as an injunction was obtained by a neighboring landowner and operations are temporarily suspended.

Hondo project, New Mexico.—The rock excavation on this project has been completed, and of the dam and canals about 60 per cent of the work yet remains to be done. About half of the work on the dam and canals has been carried on under force accounts, as the contractors gave up the contract after they had completed about 23 per cent of work.

Belle Fourche project, South Dakota.—The telephone system on this project has been completed, and about 43 per cent of the main canal may be regarded as finished.

Shoshone project, Wyoming.—Preliminary surveys of this project have been completed and contracts have been awarded for the dam and tunnel. The contractors are beginning work on these, and work may be expected to progress rapidly.

FINANCIAL STATEMENT.

RECEIPTS AND EXPENDITURES.

The fund created by the provisions of section 1 of the reclamation act is derived from the proceeds of the sale and disposal of public lands in 13 States and 3 Territories. The act was in part retroactive, putting into the fund the proceeds beginning with the fiscal year ending June 30, 1901. Upon its signature, therefore, on June 17, 1902, there were available practically two years' receipts.

No expenditures were made before the fiscal year ending June 30, 1903. The following table gives the receipts and expenditures up to the end of the last fiscal year, June 30, 1905. The figures for this last year are not exact, as the receipts have not yet been fully computed by the Treasury officials, and the accounts and claims against the fund have not yet been fully audited, there being a number of adjustments to be made dependent upon the interpretation of certain laws.

Receipts and expenditures from reclamation fund, July 1, 1900, to June 30, 1905.

Fiscal year ending June 30—	Receipts.	Expenditures.
1901	$3,144,821.91	Nothing.
1902	4,585,520.53	Nothing.
1903	8,713,996.60	$286,440.21
1904	6,826,253.59	1,461,305.01
1905	4,805,515.39	3,714,523.64
Total	28,076,108.02	5,462,268.86

The above table gives the totals for the fiscal years. The fund, however, must be considered in accordance with political divisions, as required by section 9 of the act, in which it is declared that it is the duty of the Secretary of the Interior to expend the major portion of funds arising within each State or Territory within such State or Territory, subject to the existence of feasible irrigation projects.

The term "major portion" has not been defined, but is assumed to be 51 per cent of the proceeds. There is thus what might be termed a restricted portion of the fund, namely, 51 per cent of the amount received from each State and Territory, and an unrestricted portion, or 49 per cent, of the entire fund. This unrestricted portion may be used by the Secretary according to his discretion, and can be expended in construction of feasible works in any one or more of the States and Territories named.

This provision for an unrestricted fund arose from the well-known fact that the greatest needs and opportunities of reclamation are in States and Territories from which the receipts from the disposal of public lands are least; and it has thus been practicable to start work in such localities without the delay incident to its initiation in States where irrigation is least needed, and where there is little desire on the part of the present landowners to incur the expense incident to reclamation.

The following table gives in alphabetic order the States and Territories from which the funds for the years 1901 to 1905 have been derived, the restricted portion of the funds, and the total expenditures already made on behalf of these States and Territories up to June 30, 1905. The expenditures are given in detail in the reports on the projects.

In this apportionment of expenditures, the cost of administration of the Washington office, and of engineering and expert advice has been included, all of these items of general expenditure being apportioned to one State or another. This apportionment is subject to revision as developments proceed, because much of the work lies along or near State lines, and much of the expenditure made in one State in connection with storage reservoirs or headworks of large canals will be ultimately chargeable to land in adjacent States, because of the direct benefits derived by these lands. It is impossible at the outset to make this apportionment on a final basis because of the uncertainties connected with the exact future development of these large bodies of land.

Sources and condition of the reclamation fund.

State or Territory.	Total reclamation fund to June 30, 1905.	Restricted fund=51 per cent.	Expenditures to June 30, 1905.
Arizona	$243,768.19	$124,321.78	$1,391,105.82
California	2,323,057.69	1,184,759.42	292,189.30
Colorado	1,969,733.89	1,004,564.28	295,523.06
Idaho	2,034,699.52	1,037,696.75	213,320.27
Kansas	139,874.69	71,336.19	10,682.26
Montana	2,146,687.45	1,094,810.60	190,186.92
Nebraska	671,849.57	342,643.28	148,407.50
Nevada	64,929.12	33,113.85	2,067,408.71
New Mexico	521,349.30	265,888.14	169,974.58
North Dakota	4,440,591.94	2,264,701.89	112,055.97
Oklahoma	3,127,703.37	1,595,128.72	18,768.46
Oregon	4,769,380.34	2,432,383.97	144,628.15
South Dakota	1,023,172.13	521,817.79	67,516.72
Utah	362,076.39	184,658.96	68,982.33
Washington	3,051,433.01	1,556,230.84	112,040.95
Wyoming	1,185,801.42	604,758.72	159,477.86
Total	28,076,108.02	14,318,815.18	5,462,268.86

LIABILITIES.

In addition to the actual expenditures from the reclamation fund, consideration must be had of certain liabilities diminishing the balance available for expenditure. These liabilities consist for the most part of a few large contracts entered into for the construction of works, the operations on which will extend over several years. All such contracts are entered into in compliance with the terms of section 4 of the reclamation act, providing that before letting any contracts for portions or sections of the work the necessary funds must be available.

This wise provision is in accord with the general law governing such matters, and great care is being taken in this regard. At the same time, plans are being made for expenditures dependent upon future receipts to the fund, in order that by having comprehensive plans the work may be carried on systematically and economically.

The following list of liabilities gives, by States and Territories, arranged in alphabetic order, the estimated amounts due on contracts and the amounts already paid. Many of these contracts were under consideration and were not signed on June 30, 1905, and the list, which has been brought down to November 1, 1905, is therefore not strictly comparable with the above estimates, which through the necessities of the case end with the last fiscal year.

Liabilities under contracts entered into to October 31, 1905.

State or Territory.	Project.	Estimated total.	Amounts paid.	Balance.
Arizona	Salt River	$1,979,860.25	$502,428.45	$1,477,431.80
California-Arizona	Yuma	863,975.00	8,558.76	855,416.24
Colorado	Uncompahgre[a]	607,366.47	91,800.23	515,566.24
Idaho	Minidoka	1,154,173.00	218,387.53	935,785.47
Kansas				
Montana	Huntley	256,479.00		256,479.00
Nebraska-Wyoming	North Platte	961,082.00	65,138.92	895,943.08
Nevada	Truckee	2,110,398.16	2,009,204.82	101,193.34
New Mexico	Hondo[a]	26,087.04	26,087.04	
North Dakota-Montana	Lower Yellowstone	679,484.00	8,491.11	670,992.89
Oklahoma				
Oregon-California				
South Dakota	Belle Fourche	211,349.00	56,240.98	155,108.02
Utah				
Washington				
Wyoming	Shoshone	1,110,055.00		1,110,055.00
Total		9,960,308.92	2,986,337.84	[b]6,973,971.08

[a] Does not include contracts given up by Taylor-Moore Construction Co.

[b] Equals 71.5 per cent of total contracts.

In addition to these large liabilities there are many small contracts, involving a few dollars each, and which in total sum are unimportant. They pertain merely to the daily routine of small purchases of fuel, subsistence, and supplies necessary for maintenance of office and construction camp, and to such items as lease of pasturage, telephone service, hire of storage, etc.

ESTIMATED FUTURE RECEIPTS AND EXPENDITURES.

In order to prepare plans for the near future intelligently, it is necessary to keep in mind the probable increments to the reclamation fund. Most of the work already begun or to be undertaken will be completed in 1907 or 1908. It has been deemed wise, therefore, to make plans embracing expenditures up to June 30, 1908. In order to do this, the probable receipts from the fund have been obtained from the General Land Office and are given below in connection with the receipts for previous years. The amounts given represent the receipts and the estimated receipts for the fiscal years ending June 30 in the years specified.

Schedule of estimated receipts and expenditures.

Year.	Receipts.	Total at end of year.	Expenditures each year.	Total expenditures at end of year.	Balance at end of year.
1901	$3,144,821.91				$3,144,821.91
1902	4,585,520.53	$7,730,342.44			7,750,342.44
1903	8,713,996.60	16,444,339.04	$286,440.21	$286,440.21	16,157,888.83
1904	6,826,253.59	23,270,592.63	1,461,305.01	1,747,745.22	21,522,747.41
1905	4,805,515.39	28,076,108.02	3,714,523.64	5,462,268.86	22,613,839.16
1906	[a] 3,250,000.00	31,326,108.02	[b] 6,000,000.00	11,462,268.86	19,863,839.16
1907	[a] 3,000,000.00	34,326,108.02	[b] 10,000,000.00	21,462,268.86	12,863,839.16
1908	[a] 2,750,000.00	37,076,108.02	[b] 8,000,000.00	29,462,268.86	7,613,839.16

[a] Estimate of General Land Office.

[b] Estimated.

PURCHASES OF RIGHTS OR PROPERTY.

Section 7 of the reclamation act provides that where in carrying out the provisions of the act it is necessary to acquire any rights or property, the Secretary of the Interior may acquire them for the United States by purchase or by condemnation under judicial process.

The following is a list of the purchases thus far made under this section of the act:

Purchases of rights or property.

SALT RIVER PROJECT, ARIZONA.

Vendor.	Description.	Consideration.	Remarks.
Armer, Henry and Lucinda.	E. ¼ NW. ¼, SW. ¼ NE. ¼, NW. ¼ SE. ¼ sec. 19, T. 4 N., R. 13 E., G. and S. R. M., Gila County, Ariz., 160 acres and water rights.	$3,500.00	Deed dated May 25, 1904; $500 of purchase money paid by Maricopa Company.
Henderson, A. J., and wife.	S. ½ SE. ¼ sec. 35, T. 4 N., R. 13 E., G. and S. R. M., Arizona, 80 acres and water rights.	8,500.00	Deed dated Mar. 1, 1904.
Hocker, Herbert	S. ½ NE. ¼, NE. ¼ SE. ¼, and SE. ¼ NW. ¼ sec. 27, T. 4 N., R. 13 E., G. and S. R. M., 160 acres, Arizona.	1,300.00	Deed dated Oct. —, 1905.
Hudson Reservoir and Canal Co.	Right of way map approved Oct. 6, 1890; right to flood about 10,000 acres, and water rights.	40,000.00	Deed dated July 19, 1904.
Martin, C. T	SE. ¼ SE. ¼ sec. 1, T. 4 N., R. 11 E., and SW. ¼ SW. ¼ sec. 6, and N. ½ NW. ¼, sec. 7, T. 4 N., R. 12 E., G. and S. R. M., Arizona, 152 acres.	500.00	Deed dated May —, 1905.
Nelson, John W	W. ½ NW. ¼ sec. 28, T. 4 N., R. 15 E., G. and S. R. M., Arizona, 80 acres.	600.00	Deed dated July —, 1905.
Pascoe, T. A	S. ½ SW. ¼ and 5 acres 1,320 feet long and 165 feet wide on the S. end of SW. ¼ SE. ¼ sec. 28, and N. ½ NW. ¼ and NW. ¼ NE. ¼ sec. 33, T. 4 N., R. 13 E., G. and S. R. M., 205 acres, also water right.	12,000.00	Deed dated Sept. 5, 1903.
Plunkett, S. S	Right of way across SE. ¼ SE. ¼ sec. 36, T. 4 N., R. 13 E., Arizona, and water right.	100.00	Deed dated July 21, 1904.

Purchases of rights or property—Continued.

SALT RIVER PROJECT, ARIZONA—Continued.

Vendor.	Description.	Consideration.	Remarks.
Smith, J. A	NE. ¼ NE. ¼ sec. 19 and NW. ¼ NW. ¼ sec. 20, T. 4 N., R. 12 E., G. and S. R. M., Arizona, 80 acres, also water right, ditch, etc.	$600.00	Deed dated Aug. —, 1905.
Sturgeon, J. E	Lots 2. 3, and 4, sec. 31, T. 4 N., R. 14 E., G. and S. R. M., Arizona, 111.14 acres, and water right.	2,500.00	Deed dated May 5, 1904.
Wehrli, J. C	Lots 5, 6, 7 and SE. ¼ SW. ¼ sec. 6, T. 3 N , R. 14 E., G. and S. R. M., Arizona, also water right.	1,500.00	Deed dated Feb. —, 1905.
Zschoegner, H	SW. ¼ NE. ¼ and NW. ¼ SE. ¼ sec. 30, T. 4 N., R. 13 E., G. and S. R. M., Arizona, 80 acres.	2,500.00	Deed dated July —, 1905.

YUMA PROJECT, CALIFORNIA–ARIZONA.

Vendor.	Description.	Consideration.	Remarks.
A. L. Dean and wife	E. ½ SE. ¼ sec. 6, E. ½ NE. ¼ sec. 7 and SE. ¼ sec. 7, T. 7 S., R. 21 W., G. and S. R. B. and M., 320 acres.	$5,657.00	Deed dated May 22, 1905.
Do	W. ½ SE. ¼ sec. 6 and W. ½ NE. ¼ sec. 7, T. 7 S., R. 21 W., G. and S. R. M., 160 acres.	2,614.00	Do.
C. H. Meadows and wife.	NW. ¼ sec. 7, T. 7 S., R. 21 W., G. and S. R. B. and M., 160 acres.	2,100.00	Deed dated May 11, 1905.
Do	SW. ¼ sec. 7 and NW. ¼ sec. 18, from C. H. Meadows, and NW. ¼ sec. 7, from Ida M. Meadows, all in T. 7 S., R. 21 W., G. and S. R. M., Arizona. 320 acres.	4,200.00	Do.
Roller, C. C	S. ½ NE. ¼, S. ½ NW. ¼, and NE. ¼ NW. ¼ sec. 13, T. 7 S., R. 22 W., G. and S. R. M., Arizona, 200 acres.	1,100.00	Deed dated Aug. —, 1905.

UNCOMPAHGRE VALLEY PROJECT, COLORADO.

Vendor.	Description.	Consideration.	Remarks.
Block, C. A	Block 29, Marchant & Peabody's subdivision of Selig's addition to Montrose, Colo.	$450.00	Deed dated Mar. 20, 1905.

MINIDOKA PROJECT, IDAHO.

Vendor.	Description.	Consideration.	Remarks.
Samson-Gifford Co	SW. ¼ SW. ¼ and lots 1, 2, and 3, sec. 17; lot 5, sec. 20; lots 6 and 7, sec. 19; lots 1 and 2 and N. ½ SW. ¼ sec. 16; lot 5, sec. 21, T. 9 S., R. 28 E., B. M., Idaho, 428.7 acres.	$13,160.00	Deed dated Aug. —, 1905.
Smith, A. H., and wife.	SW. ¼ SE. ¼ lot 2, sec. 8; NE. ¼ NE. ¼ and lots 5 and 6, sec. 17, T. 9 S., R. 27 E., B M., Idaho, 158.7 acres.	1,900.00	Deed dated June 2, 1905.

NORTH PLATTE PROJECT, NEBRASKA.

Vendor.	Description.	Consideration.	Remarks.
North Platte Canal and Colonization Co.	Canal right of way	(a)	Contract executed by Secretary of Interior Dec. 22, 1904.

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[a] Carriage of water for North Platte Canal and Colonization Co., maintenance charges to be paid by water users.

Purchases of rights or property—Continued.

TRUCKEE-CARSON PROJECT, NEVADA.

Vendor.	Description.	Consideration.	Remarks.
Mercantile Trust Co.	64.25 acres in sec. 7, T. 15 N., R. 17 E., M. D. B. and M., Placer County, Cal., at outlet Lake Tahoe.	$6,300.00	Deed dated Aug. 9, 1904.
Occidental Land and Improvement Co.	5,076 22 acres in Lyon and Churchill counties, Nev.	28,185.22	Deed dated Mar. 6, 1905.
Pray, Helen A., et al.	SE. ¼ sec. 33, T. 18 N., E. ½ NW. ¼ and NE. ¼ sec. 4, and fractional N. ½ sec. 3, T. 17 N., R. 25 E., M. D. M., Nevada, 719.62 acres.	2,157.00	Deed dated Aug. 9, 1904.

HONDO PROJECT, NEW MEXICO.

Vendor.	Description.	Consideration.	Remarks.
Hagerman, J. J., and wife, and Roswell Land and Water Co.	SW. ¼ sec. 24, N. ½ NW. ¼ and SW. ¼ NW. ¼ sec. 25, E. ½ NE. ¼, N. ½ SE. ¼ and SW. ¼ NE. ¼ sec. 26, T. 11 N., R. 22 E., 480 acres; also SW. ¼ SW. ¼ sec. 25, S. ½ S. ½ sec. 26, SE. ¼ SE. ¼ sec. 27, NE. ¼ NE. ¼ and NW. ¼ NW. ¼ sec. 35, T. 11 N., R. 22 E., 320 acres, N. M. M., New Mexico, Hondo reservoir site, and water rights.	$20,000.00	Deeds dated Dec 8, 1905.

CONTRACTS.

CONSTRUCTION CONTRACTS.

Section 4 of the reclamation act gives the Secretary authority to let contracts for constructing the work in such portions or sections as it may be practicable to construct and to complete as parts of the whole project. In accordance with the requirements of this section, the surveys and examinations are brought as quickly as possible to a point where contracts may be let for portions of the work. As soon as one contract is let, the examinations are pushed forward rapidly to a point where another integral unit can be taken up.

In order to expedite construction, the plans are rapidly outlined, and when the feasibility of the whole project has been determined, immediate action is taken toward beginning construction without waiting for all of the minor details to be settled. Hence, construction has usually been begun upon one part or another long before the final surveys have been finished for the project as a whole. In drawing up the large contracts provision has been made for this condition. All large contracts have been entered into upon a unit basis as to cost per cubic yard of dirt moved or concrete laid, the change in final details being at all times an essential part of the contract. This has enabled modifications to be made as the work progresses. Instead of waiting months or years to perfect every detail, it has thus been possible to get the work started and, as the ground has been opened and conditions have become better known, to modify the shape of the structures to suit the new conditions.

Although the greater part of the expenditure is made under a few relatively large contracts, there is in the aggregate a considerable amount of work which must be done under what is known as "force account," by the employment of men by the day. Much of the preliminary work, such as boring for foundations, putting in test pits, constructing roads, etc., can be handled only in this way.

The maintenance, also, of the completed work is a matter which can be carried on only by force account. Thus there is a steadily increasing necessity for a system which will enable the force account work to be carried on economically and effectively. There have also been instances where the contractors have failed, and where it has been necessary for the work to be taken from their hands and continued by force account, under the direct supervision of the engineers of the Reclamation Service.

The present system of letting contracts is unquestionably the best on any class of work capable of accurate description. It is the method which is employed by all large corporations, and where discretion is used excellent results follow. As a rule, the profits to the contractors on the reclamation work have not been large; and, in fact, there is more danger of loss to the contractors, and consequent poor work, than of inordinate profits. One of the chief difficulties encountered has been that growing out of the attempt of inexperienced or irresponsible persons to get an award of a contract. There is prevalent a mistaken idea that a Government contract is a sure road to wealth, and a number of persons who are wholly unprepared by past experience have competed by offering bids in regular form. Some of these bids, on examination, have been found to be based on ignorance, for the prices offered are less than the amount for which the work can possibly be done. Where the prices have been ridiculously disproportionate to the work, it has been possible to reject the bid altogether; but the chief danger lies in those cases in which the prices are not so extremely low that the bids can be absolutely disregarded.

Some men who have had moderate experience on private work, and who can not properly be classed as wholly ignorant of contract operations, contrive to get together sufficient capital to enable them to bid, and these may underbid more experienced contractors and, if they have good luck, may be able to complete the work without great loss. These men depend largely upon the hope that they can succeed in getting some modification of the letter of the specifications or some special privileges, and do not give sufficient weight to the need of fulfilling absolutely all the requirements of the contract. In short, they hope by good luck and ingenious evasion ultimately to get through the work in some fashion.

To deal with would-be contractors of this class has been difficult and irritating. In some cases the boards of engineers have been morally certain that these men could not carry out the work, and yet have not been able to obtain actual proof of that fact, as the commercial standing of the would-be contractors has been fairly good, they have had some experience, and there is always the unknown factor of good luck which keeps some men out of disaster. If the individual members of the board were handling the matter as a private affair, they would reject such bids; but as public officials they must be prepared to give proof of the soundness of their judgment. If, on general principles, they recommend the rejection of the lowest bid they are at once exposed to charges of favoritism. Hence, bids must sometimes be awarded to the lowest bidder when there is reasonable doubt in the minds of all concerned as to the wisdom of the award. Then follows a long struggle, involving daily warfare between the engineering and inspecting force and the contractor in the effort to compel him to fulfill the terms of the contract. The contractor, realizing that his profits will be small or that he is losing money day by day, resorts to every device that human ingenuity can conceive to save here and there, and there is a daily contest of wits and almost of brute force in order to carry out the work.

During 1905 there has been a rapid development of railroad building in the West and of construction of all kinds. Labor, at best a scarcity in the market, has become more and more difficult to obtain, wages have advanced greatly, and the efficiency and steadiness of labor has decreased. Hence the contracts entered into in 1904 or in the early part of 1905 have become increasingly difficult to fulfill, and some of the smaller contractors have been forced to the wall. The cost of materials has also greatly advanced, and where time has been an element there have been serious losses from this source. The experienced subcontractors have nearly all been loaded up with work, and the main contractors have found it exceedingly difficult to carry out the operations at the speed agreed upon.

Although the Government contracts do not recognize the subcontractor, yet, as a matter of fact, all large work is performed by subcontractors, the man or firm obtaining the contract from the Government furnishing, as a rule, the working capital and becoming the responsible superintendent. The anomalous condition is one which should be recognized, as the attempt to carry on Government business in a form different from that of ordinary commercial affairs invariably leads to unnecessary expense and difficulty.

The following tables show the status of all contracts heretofore made under the several projects:

Status of construction contracts, October 31, 1905.

SALT RIVER PROJECT, ARIZONA.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
Wilcox & Rose	Cement mill	$12,505.56	$12,505.56	100	100
Allis-Chalmers Co	Cement-mill machinery	38,880.00	38,880.00	100	100
James R. Thorpe	Telephone system	22,711.43	22,711.43	100	100
Hendrie & Bolthoff Manufacturing Co.	Cement-mill motors	10,641.50	10,641.50	100	100
Bullock Electric Manufacturing Co.	Generators for temporary power plant.	9,687.50	9,687.50	100	100
Stillwell-Bierce & Smith-Vaile Co.	Water wheels	8,445.00	5,000.00	59	100
Robert Sherer & Co	Power canal excavations and structures.	220,000.00	201,267.05	91	98
John Tuttle	Power canal tunnels	166,623.66	166,623.66	100	100
Do	Sluicing tunnel	11,178.00	11,178.00	100	100
Llewellyn Iron Works	Sluicing gates	102,000.00	2,668.80	2	5
Wolf Sachs	Hauling	50,000.00	7,569.80	15	15
C. R. Eager & Co	Fuel oil	174,000.00	8,662.55	5	5
J. E. Sturgeon	Firewood	5,032.60	5,032.60	100	100
J. M. O'Rourke & Co	Roosevelt dam	1,147,600.00		0	0
Total		1,979,305.25	502,428.45		

YUMA PROJECT, CALIFORNIA-ARIZONA.

J. G. White & Co	Laguna dam	$797,650.00	$8,558.76	1	2½
Miller & Peasley	Dikes	66,825.00		0	9
Pacific Portland Cement Co.[a]	Cement	62,000.00		0	0
Total		863,975.00	8,558,76		

[a] In preparation.

Status of construction contracts, October 31, 1905—Continued.

UNCOMPAHGRE VALLEY PROJECT, COLORADO.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
Taylor-Moore Construction Co.[a]	Gunnison tunnel	$1,008,500.00	$18,890.05	2	15
Ed. A. Hess	Telephone system	5,641.60	5,641.60	100	100
Knowlton & Bollen Construction Co.	South canal, divisions 1, 2, 7, 8, 9.	41,010.38	41,010.38	100	100
Orman & Crook	South canal, divisions 3, 4, 5.	33,509.85	33,509.85	100	100
Kellogg & Worley	South canal, division 6	8,873.64	8,873.64	100	100
J. J. Kewin	Office building	4,166.00	2,764.76	66	100
Montrose Hardware Co.	Heating plant for office building.	800.00		0	0
Orman & Crook	South canal, divisions 10–21.	513,365.00		0	9
Total		1,615,866.47	110,690.28		

MINIDOKA PROJECT, IDAHO.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
Bates & Rogers Construction Co.	Dam, spillway, and canal.	$425,928.00	$184,629.96	32	51
Portland Cement Co. of Utah.	Cement	41,300.00	12,854.80	31	44
Hubbard & Carlson	Distributing canal, schedule 2.	121,494.00	20,744.04	17	33
W. H. Crumb & Co	Telephone system	6,335.00		0	0
Orman & Crook	Distributing canal, schedules 1, 5, 6, and 7.	354,828.00	40,702.41	11	25
Vulcan Iron Works	Distributing canal, schedules 3 and 4.	9,471.00		0	0
Monarch & Porter	Distributing canal, schedule 8.	194,827.00	9,456.32	5	11
Total		1,154,173.00	218,387.53		

HUNTLEY PROJECT, MONTANA.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
W. D. Lovell	Structures	$33,764.00		0	1
Illinois Steel Co	Cement	7,700.00		0	0
Cotton Bros. & Co.[b]	Main canal, division 1	118,560.00		0	0
W. D. Lovell[b]	Main canal, division 2	43,245.00		0	0
Callahan, Katz, Phelan & Shirley.[b]	Main canal, division 3	53,210.00		0	0
Total		256,479.00			

LOWER YELLOWSTONE PROJECT, MONTANA–NORTH DAKOTA.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
Elmer A. Hess	Telephone system	$14,939.00	$3,910.85	26	40
Deadwood Construction Co.	Structures, division 4	28,143.00	1,379.40	5	10
Callahan Bros., Phelan & Shirley.	Canal, divisions 2 and 3	356,758.00		0	0
Widell-Finley Co	Canals, division 1	163,368.00	836.99	.5	7
Chas. Stabern	Structures, divisions 1, 2, and 3.	104,276.00	2,363.87	2	5
Illinois Steel Co	Cement	12,000.00		0	33
Total		679,484.00	8,491.11		

[a] Contract given up by contractors.

[b] In preparation October 31, 1905.

Status of construction contracts, October 31, 1905—Continued.

NORTH PLATTE PROJECT, NEBRASKA-WYOMING.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
Kilpatrick Bros. & Collins Co.	Pathfinder tunnel	$34,292.00	$29,556.75	86	100
Robinson & Maney	Interstate canal, divisions 1, 2, 6, 7, 9, and 10.	216,368.00	9,836.98	5	12
Griffith & McDermott	Interstate canal, division 3.	78,135.00	2,230.40	3	7
Orman & Crook	Interstate canal, division 5.	76,647.00	12,198.10	16	27
James O'Connor	Interstate canal, division 8.	37,560.00	5,831.17	16	23
Deadwood Construction Co.	Interstate canal, division 4.	32,695.00	5,485.52	17	38
James F. Stanley	Bridge	3,385.00		0	100
Geddes & Seerie Stone Co.	Pathfinder dam	482,000.00		0	0
Total		961,082.00	65,138.92		

TRUCKEE-CARSON PROJECT, NEVADA.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
E. B. & A. L. Stone Co.	Main canal, division 3	$339,118.80	$339,118.80	100	100
C. A. Warren & Co.	Main canal, divisions 1 and 2.	965,943.25	965,943.25	100	100
J. D. Spreckels & Bros. Co.	Cement	89,818.65	89,818.65	100	100
Clarence W. Swain	Bridges	4,288.00	2,040.00	48	100
Pacific Coast Construction Co.	Distributing canals, excavation.	254,777.26	254,777.26	100	100
San Francisco Construction Co.	Distributing canals, structures.	53,947.76	53,947.76	100	100
R. C. Mattingly	Distributing canals, headworks.	60,773.13	60,773.13	100	100
San Francisco Construction Co.	Ditches, divisions 1, 2, and 6.	129,587.00	102,457.03	79	95
Pacific Coast Construction Co.	Ditches, division 5	43,436.31	43,436.31	100	100
Utah Construction Co.	Ditches, divisions 3 and 4	117,737.00	81,871.63	70	95
Pacific Portland Cement Co.	Cement	15,021.00	15,021.00	100	100
Edward Malley	Lake Tahoe regulating works.	32,200.00		0	0
Pacific Portland Cement Co.	Cement	3,750.00		0	0
Total		2,110,398.16	2,009,204.82		

HONDO PROJECT, NEW MEXICO.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
Taylor-Moore Construction Co.[a]	Dam and canals, schedules 1, 3, 4, 5, 6.	$118,403.00	$13,939.88	12	[b] 40
Slinkard Construction Co.	Rock excavation, schedule 2.	26,087.04	26,087.04	100	100
Total		144,490.04	40,026.92		

[a] Contract given up by contractors.

[b] 17 per cent completed under force account.

Status of construction contracts, October 31, 1905—Continued.

BELLE FOURCHE PROJECT, SOUTH DAKOTA.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
S. R. H. Robinson	Main canal, division 1	$99,937.00	$24,166.49	24	31
Widell-Finley Co	Main canal, division 2	107,260.00	28,736.40	27	46
W. H. Crumb & Co	Telephone system	4,152.00	3,338.09	80	100
Total		211,349.00	56,240.98		

SHOSHONE PROJECT, WYOMING.

Prendergast & Clarkson	Shoshone dam	$515,730.00		0	0
Charles Spear	Corbett tunnel	594,325.00		0	0
Total		1,110,055.00			

MISCELLANEOUS CONTRACTS.

Miscellaneous contracts and leases made by the Reclamation Service.

ARIZONA.

Name.	Date.	Subject.
	1905.	
Aldridge, Dan	Aug. 1	Hauling 40,000 feet of lumber.
Anderson, L. A	do	Hauling 1,000 feet of lumber.
Barclay, Higdon & Co	July 29	Hauling oil.
Berray, N. S	July 1	Rent of warehouse, Globe.
Central Avenue Improvement Co	do	Rent of Phoenix office.
Chilchuana, Henry	Aug. 1	Hauling 20,000 feet of lumber.
Collins, D. E	do	Cutting 500,000 feet of lumber.
Engasser, M	do	Hauling 40,000 feet of lumber.
Fernandez, C	do	Cutting 300 cords of wood.
Figuroa, Abel	do	Hauling 40,000 feet of lumber.
Hemington, Ernest	do	Hauling 10,000 feet of lumber.
Hicks, R	do	Hauling 40,000 feet of lumber.
Hinton, S. H	do	Do.
Ingram, Lon	do	Do.
Jenkins, A. R	do	Do.
May, J. T	do	Hauling 4,000 feet of lumber.
Mills, F. J	June 1	Use of drilling plant.
Morris, Harvey	Aug. 1	Hauling 40,000 feet of lumber.
Norton, L. B	do	Do.
Sheppard, R. J	do	Hauling 5,000 feet of lumber.
Striplin, J. L	do	Hauling 40,000 feet of lumber.
Vinyard, G. L	do	Hauling 30,000 feet of lumber.

Status of construction contracts, October 31, 1905—Continued.

NORTH PLATTE PROJECT, NEBRASKA-WYOMING.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
Kilpatrick Bros. & Collins Co.	Pathfinder tunnel	$34,292.00	$29,556.75	86	100
Robinson & Maney	Interstate canal, divisions 1, 2, 6, 7, 9, and 10.	216,368.00	9,836.98	5	12
Griffith & McDermott	Interstate canal, division 3.	78,135.00	2,230.40	3	7
Orman & Crook	Interstate canal, division 5.	76,647.00	12,198.10	16	27
James O'Connor	Interstate canal, division 8.	37,560.00	5,831.17	16	23
Deadwood Construction Co.	Interstate canal, division 4.	32,695.00	5,485.52	17	38
James F. Stanley	Bridge	3,385.00		0	100
Geddes & Seerie Stone Co.	Pathfinder dam	482,000.00		0	0
Total		961,082.00	65,138.92		

TRUCKEE-CARSON PROJECT, NEVADA.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
E. B. & A. L. Stone Co.	Main canal, division 3	$339,118.80	$339,118.80	100	100
C. A. Warren & Co.	Main canal, divisions 1 and 2.	965,943.25	965,943.25	100	100
J. D. Spreckels & Bros. Co.	Cement	89,818.65	89,818.65	100	100
Clarence W. Swain	Bridges	4,288.00	2,040.00	48	100
Pacific Coast Construction Co.	Distributing canals, excavation.	254,777.26	254,777.26	100	100
San Francisco Construction Co.	Distributing canals, structures.	53,947.76	53,947.76	100	100
R. C. Mattingly	Distributing canals, headworks.	60,773.13	60,773.13	100	100
San Francisco Construction Co.	Ditches, divisions 1, 2, and 6.	129,587.00	102,457.03	79	95
Pacific Coast Construction Co.	Ditches, division 5	43,436.31	43,436.31	100	100
Utah Construction Co.	Ditches, divisions 3 and 4.	117,737.00	81,871.63	70	95
Pacific Portland Cement Co.	Cement	15,021.00	15,021.00	100	100
Edward Malley	Lake Tahoe regulating works.	32,200.00		0	0
Pacific Portland Cement Co.	Cement	3,750.00		0	0
Total		2,110,398.16	2,009,204.82		

HONDO PROJECT, NEW MEXICO.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
Taylor-Moore Construction Co.[a]	Dam and canals, schedules 1, 3, 4, 5, 6.	$118,403.00	$13,939.88	12	[b] 40
Slinkard Construction Co.	Rock excavation, schedule 2.	26,087.04	26,087.04	100	100
Total		144,490.04	40,026.92		

[a] Contract given up by contractors.
[b] 17 per cent completed under force account.

Status of construction contracts, October 31, 1905—Continued.

BELLE FOURCHE PROJECT, SOUTH DAKOTA.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
S. R. H. Robinson	Main canal, division 1	$99,937.00	$24,166.49	24	31
Widell-Finley Co.	Main canal, division 2	107,260.00	28,736.40	27	46
W. H. Crumb & Co	Telephone system	4,152.00	3,338.09	80	100
Total		211,349.00	56,240.98		

SHOSHONE PROJECT, WYOMING.

Contractor.	Work or material.	Estimated amount of contract.	Vouchers approved for payment.	Percentage paid.	Percentage of work completed.
Prendergast & Clarkson	Shoshone dam	$515,730.00		0	0
Charles Spear	Corbett tunnel	594,325.00		0	0
Total		1,110,055.00			

MISCELLANEOUS CONTRACTS.

Miscellaneous contracts and leases made by the Reclamation Service.

ARIZONA.

Name.	Date.	Subject.
	1905.	
Aldridge, Dan	Aug. 1	Hauling 40,000 feet of lumber.
Anderson, L. A	...do...	Hauling 1,000 feet of lumber.
Barclay, Higdon & Co	July 29	Hauling oil.
Berray, N. S	July 1	Rent of warehouse, Globe.
Central Avenue Improvement Co	...do...	Rent of Phoenix office.
Chilchuana, Henry	Aug. 1	Hauling 20,000 feet of lumber.
Collins, D. E	...do...	Cutting 500,000 feet of lumber.
Engasser, M	...do...	Hauling 40,000 feet of lumber.
Fernandez, C	...do...	Cutting 300 cords of wood.
Figuroa, Abel	...do...	Hauling 40,000 feet of lumber.
Hemington, Ernest	...do...	Hauling 10,000 feet of lumber.
Hicks, R	...do...	Hauling 40,000 feet of lumber.
Hinton, S. H	...do...	Do.
Ingram, Lon	...do...	Do.
Jenkins, A. R	...do...	Do.
May, J. T	...do...	Hauling 4,000 feet of lumber.
Mills, F. J	June 1	Use of drilling plant.
Morris, Harvey	Aug. 1	Hauling 40,000 feet of lumber.
Norton, L. B	...do...	Do.
Sheppard, R. J	...do...	Hauling 5,000 feet of lumber.
Striplin, J. L	...do...	Hauling 40,000 feet of lumber.
Vinyard, G. L	...do...	Hauling 30,000 feet of lumber.

Miscellaneous contracts and leases made by the Reclamation Service—Continued.

CALIFORNIA.

Name.	Date.	Subject.
	1905.	
Elite Toilet Service Co	July 1	Toilet service.
Home Telegraph and Telephone Co	Aug. 15	Telephone service.
Merchants' Exchange	May 1	Rent of office, San Francisco.
Pacific Electric Railway Co	June 25	Rent of office, Los Angeles.
Union Towel and Case Co	July 1	Towel service.
Union Trust Co	Apr. 28	Rent of office, Braly Building Los Angeles.

COLORADO.

	1905.	
Colorado Telephone Co	June 16	Telephone service.
Denver Chamber of Commerce and Board of Trade	May 13	Rent of Denver office.
Deeble & Gibson	July 1	Rent of Montrose office.
DuPont, E. I., Co	Aug. 1	Explosives.
Gibson Lumber Co	...do...	Lumber and building materials.
Hallack & Howard Lumber Co	July 1	Do.
Rowley, C. H	July 20	Hauling coal.

IDAHO.

	1905.	
Sonna, Peter	June 30	Rent of Boise office.

KANSAS.

	1905.	
Hayes, Ed. S	Sept. 15	Storage of property.
McBeth & Kinnison	May 20	Rent of Garden City office.

MONTANA.

	1905.	
Becker, Edward H	Aug. 10	Rent of Billings office.
Berry, Edward J	Aug. 1	Rent of Glendive office.
Billings Mutual Telephone Co	June 1	Telephone service.
Hiles, W. E	Sept. 9	Rent of Chinook office.
Stanley, Henry H	June 30	Rent of Great Falls office.

NEBRASKA.

	1905.	
Powers, John	June 26	Rent of Mitchell office.

NEVADA.

	1905.	
Beasley, Jas. W	Apr. 12	Use of horses, mules, and scrapers.
Dolf, Thos	July 1	Use of grading outfit.
Griffin, Dan	Aug. 1	Use of 150 work animals.
Webb, Geo. W	July 1	Use of horses and mules.

Miscellaneous contracts and leases made by the Reclamation Service—Continued.

NEW MEXICO.

Name.	Date.	Subject.
	1905.	
Carper, Joe	Sept. 11	Digging well.
Cazier, T. F	Aug. 1	Work animals and equipment.
Eddy Lodge, No. 21	July 18	Rent of Carlsbad office.
Fox, Herbert E	July 1	Rent of Albuquerque office.
Harris, F. H.	Aug. 1	Use of grading outfit.
Leonard, J. L	Sept. 15	Alfalfa.
McGaffey, L. K	July 1	Rent of Roswell office.
Slinkard, W. R	Aug. 1	Use of grading outfit.

NORTH DAKOTA.

	1905.	
Hedderich, G. M	June 27	Rent of Williston office.

OKLAHOMA.

	1905.	
Allen, Charlie L	June 27	Outfit for surveying party.

OREGON.

	1905.	
Armstrong, A. P	Aug. 25	Rent of Portland office.
Hendricks, C. C	July 1	Rent of Pendleton office.
Summers, S. T	Sept. 1	Rent of Klamath Falls office.

SOUTH DAKOTA.

	1905.	
McMaster, Wm. H	Sept. 1	Rent of Bellefourche office.

UTAH.

	1905.	
Taylor, C. E	July 1	Rent of Salt Lake City office.

WASHINGTON.

	1905.	
Beausoleil, Ildege	June 16	Rent of North Yakima office.
Pacific Telegraph and Telephone Co	June 27	Telephone service.

WYOMING.

	1905.	
Chicago, Burlington and Quincy Rwy. Co	Apr. 25	Rent of Fort Laramie office.
Dain, Jeremiah	Sept. 7	Rent of Casper office.
Freeland Telephone Co.	June 29	Telephone service.
Hoitsma, Syd. S	Sept. 20	Removal of buildings.
Platte Valley Telephone Co	July 1	Telephone service.
Walls, W. L	Sept. 23	Rent of Cody office.

UNIT PRICES.

In the tables below are given the unit prices of work on all contracts entered into by the Reclamation Service, except for cement. The contract prices for cement are given on pages 360–361.

Cast iron.—The specifications for cast iron were as follows: "Cast iron shall be of the best quality of soft gray iron, free from cinders, blowholes, or other imperfections, and the castings must be true to shape and dimensions as shown on the drawings. No plugging of holes will be allowed. Finished materials shall be clean, smooth, straight, true to shape, of workmanlike finish, and free from defects."

Unit price of cast iron.

Project.	Division.	Total amount.	Contract price per pound.	Remarks.
		Pounds.		
Lower Yellowstone	Main canal, division 1	1,000	$0.05	
Do	Main canal, division 2	100	.05	
Do	Main canal, division 3	100	.05	
Do	Main canal, division 4	100	.07	
Truckee-Carson	Laterals, division 1	2,100	.085	
Do	Laterals, division 2	5,200	.085	
Do	Laterals, division 3	4,200	.085	
Do	Laterals, division 4	5,200	.085	
Do	Main canal, division 6	7,400	.09	

Steel.—The general specification for steel upon which the bids in the table below are based is as follows: "Steel shall be furnished in quantities and forms required and paid for by the pound. All steel shall be good, open-hearth steel, and shall have an ultimate tensile strength of not less than 60,000 pounds per square inch." This specification contains the important requirements, but was varied in detail according to the character of the projects and the uses to which it was to be put. All bids were on furnished and erected material.

Unit prices for steel.

Project.	Division.	Total amount.	Contract price.	Remarks.
		Pounds.	*Per lb.*	
Lower Yellowstone	Headworks and structures, division 1.	7,800	$0.06	Structural steel in place.
Do	Structures, division 2	16,500	.06	
Do	Structures, division 3	7,500	.06	
Do	Structures, division 4	8,000	.08	
Do	Structures, division 1	918,000	.00$\frac{4}{10}$	Bid on placing only.
Do	Structures, division 2	207,700	.004	
Do	Structures, division 3	173,300	.004	
Do	Structures, division 4	167,200	.01	
Hondo	Reservoir, canals, etc	100,000	.07$\frac{4}{10}$	
Belle Fourche	Diversion dam	46,200	.04¼	Structural steel placed.
Do	Dam	16,000	.07	Concrete reenforcement.
Do	Canal	3,000	.07	
Truckee-Carson	Power house, division 6	8,800	.09	
Huntley	Bridges	120,000	.0288	Do.
Minidoka	South canal	30,900	.08	Free on board cars nearest railroad point.

Piles.—The general requirements for piles were that they should be 8 inches at the small end and 12 inches at the large and of good timber.

Unit prices for piles.

Project.	Division.	Linear feet.	Contract price.	Remarks.
Lower Yellowstone	Structures	7,900	$0.20	Delivered.
Truckee-Carson	Distributing system		.85	Do.
Do	do		.15	Driving only.
Belle Fourche	Dam	450	.71	Delivered and driven.

Sheet piling.—Each sheet pile shall be formed of three planks of uniform width, thickness, and length, with true tongue and groove and substantially fastened and well driven in the cases of driving.

Unit prices for piles.

Project.	Division.	Board feet delivery; driving.	Contract price.	Remarks.
		Linear feet.	*Per foot.*	
Yuma	Laguna dam	53,000	$0.40	Delivered and driven.
Lower Yellowstone	Canal headworks	25,000	.135	Delivered only.
Do	Canal, divisions 2 and 3	105,000	.135	Do.
Do	Canal, division 4	88,200	.15	Do.
Do	Main canal headworks, division 1.	5,000	.0265	Driving only.
Do	Main canal, division 2	12,400	.0265	Do.
Do	Main canal, division 3	6,890	.0265	Do.
Do	Main canal, division 4	6,000	.045	Do.
Truckee-Carson	Distributing system		.22	Delivered only.
Do	do		.08¼	Driving only.
Do	do	370	.22	Delivered per foot.
Do	do	370	1.75	Driving per pile.
Do	do	320	.18	Delivered.
Do.	do	320	1.50	Driving per pile.
Belle Fourche	Diversion dam	500		

Terra-cotta pipe.—The bids on terra-cotta pipe required that it should be of standard quality, made of the best material, thoroughly and perfectly burned, of homogeneous texture, without cracks or imperfections, well glazed, so that the inner and outer surfaces shall be hard, smooth, and even and in every way acceptable to the engineer. The pipe was to be delivered and placed, including joints and refilling trenches.

Unit prices for terra-cotta pipe.

Project.	Division.	Linear feet.	Contract price per linear foot.	Remarks.
Lower Yellowstone	Main canal, division 1	120	$2.00	24-inch.
Do	Main canal, division 2	120	2.80	Do.
Do	Main canal, division 3	110	2.80	Do.
Do	Main canal, division 4	240	2.80	Do.
Do	Main canal, division 1	120	3.50	30-inch.
Do	Main canal, division 2	120	4.20	Do.
Do	Main canal, division 3	240	4.20	Do.
Do	Main canal, division 4	360	4.20	Do.
Do	Main canal, division 1	120	5.50	36-inch.
Do	Main canal, division 2	360	7.00	Do.
Do	Main canal, division 3	360	7.00	Do.
Do	Main canal, division 4	360	7.00	Do.

Masonry.—The specifications for the Roosevelt dam provide that the masonry is to be constructed of fine grain, broken range cyclopean rubble; stones of 10 tons to be used, and the whole to be constructed of large stones as far as practicable. The stone is to be obtained near the dam site. The Hondo reservoir masonry was to be composed of limestone from quarries in the vicinity of the structure, was to be the best obtainable, with minimum dimensions of 12 inches by 15 inches by 6 inches.

Unit prices for masonry.

Project.	Division.	Amount.	Contract price per cubic yard.[a]	Remarks.
		Cu. yds.		
Salt River	Roosevelt dam	300,000	$3.15[b]	In dam.
Do	do	400	20.00[b]	Coping.
Do	do	6,000	4.75[b]	Wing walls.
Hondo	Canals and reservoir	100	8.90	
Huntley	Structures	200	3.50	Dry rubble wall
Do	Main canal, division 1	100	8.00	Dry rubble walls.
Truckee-Carson	Distributing system		5.40	

[a] Cement furnished by the United States.

[b] Sand furnished by the United States.

Concrete.—In concrete structures all cement is furnished by the United States.

Unit prices for concrete.

Project.	Division.	Amount.	Contract price per cubic yard.	Remarks.
		Cu. yd.		
Uncompahgre	Gunnison tunnel	2,000	$6.75	Concrete lining and portal masonry.
Yuma	Laguna dam	27,150	4.00	Core wall in dam.
Salt River	Roosevelt dam	600	6.00	Bridge piers.
Hondo	Canals and reservoir	1,600	6.90	
Minidoka	Dam		6.00	Core wall.
Do	do		5.00	Spillway.
Do	Canal		7.00	
Do	do		8.00	Diversion channel dam.
Truckee-Carson	Laterals, divisions 1, 2, etc.	575	10.50	Turnouts and bridges.
Do	Laterals, division 3	286	12.00	Do.
Do	Laterals, division 4	400	12.00	Do.
Do	Power house	3,260	12.00	Foundation.
Do	Distributing canal, etc		6.65	
Do	do		8.50	
Belle Fourche	Dam and reservoir	21,930	4.95	
Huntley	Structures	400	3.73	Without steel reenforcement.
Do	do	1,200	3.98	Steel reenforcement.
Do	Main canal	2,200	7.00	Not reenforced.
Do	do	100	8.00	Reenforcement steel furnished by United States.
Lower Yellowstone	Structures, division 1	210	5.00	
Do	Structures, division 2	2,500	5.00	Class 1, broken.
Do	Structures, division 3	1,940	5.00	Stone less than ¾ inch diameter.
Do	Structures, division 4	1,690	6.25	
Do	Structures, division 1	4,850	4.25	Class 2, broken.
Do	Structures, divisions 2-3	250	4.25	Stone less than 2½ inches diameter.
Do	Structures, division 4	110	5.75	Placing of steel, aid for.
Belle Fourche	Dam	15,000	7.00	Schedule A. Upstream face footing wall of dam.
Do	do	4,800	6.80	B. Gate chambers, conduits, and appurtenance. F. Miscellaneous.
Do	do	1,850	6.50	C. Curbing and gutters.
Do	do	280	6.80	D. Waste conduit, etc.
Do	Canals	850	7.25	E. Bridges, canals, sluice, and culverts.

Rock fill.—The requirements for a rock fill in the Laguna bids were that at least two-thirds of the total quantity shall consist of blocks of not less than 1,000 pounds, one-half of which at least shall consist of blocks of 4,000 pounds, the rock being dumped from an elevation of 5 feet or more. In the Minidoka dam the required size of rocks varied from 1,000 to 4,000 pounds, to be dropped from an elevation of 10 feet.

Unit prices for rock fill.

Project.	Division.	Amount.	Contract price per cubic yard.	Remarks.
		Cu. yds.		
Yuma	Laguna dam	305,000	$0.85	
Minidoka	Dam		.90	
Do	Spillways		.75	

Riprap.—The conditions are briefly stated under "Remarks" in the table, they being so varied as to make generalization impossible.

Unit prices for riprap.

Project.	Division.	Amount.	Contract price per square yard.	Remarks.
		Sq. yds.		
Hondo	Divisions 1, 3, 4, 5	26,500	$0.42	Riprap stones not less than 1 foot thick.
Do	Division 2	100	.85	Do.
Do	Division 6	408	.42	Do.
Huntley	Division 1	750	2.75	Do.
Do	Division 2	1,200	3.50	Do.
Do	Structures	1,000	3.50	Do.
Minidoka	Dam		2.00	Minimum thickness, riprap, 18 inches; stones, 1 foot.
Do	Canal	12,160	1.25	Do.
Lower Yellowstone	Canal division 1	2,400	1.99	To be laid on 12-inch base of gravel.
Do	Canal division 2	25,800	1.99	Do.
Do	Canal division 3	12,900	1.99	
Do	Canal division 4	13,530	2.00	
Belle Fourche	Division 1		2.50	Minimum stone in any dimension, 18 inches.
Truckee-Carson	Spillway, falls, etc		4.00	Loosely placed.
Uncompahgre	Gunnison tunnel		3.00	Do.

Tunnels.—The specifications for tunneling require the bid to include excavation, removal of timbering, concrete lining, ventilating, draining, and pumping to the extent of 10,000 gallons per twenty-four hours. In the Uncompahgre Valley project the material was classed as follows: Class 1, hard rock that will not require concrete lining; class 2, material as in 1, with arched lining overhead; class 3, material that will stand without timber until lined with concrete; class 4, material that must be timbered during excavation and lined with concrete. In the Huntley project there is an additional clause requiring timbers and logging, timbers in all cases to remain after lining with concrete.

Unit prices for tunnels.

Project.	Division.	Amount	Contract price per linear foot.	Remarks.
		Lin. feet.		
Uncompahgre	Gunnison tunnel	11,500	[a]$34.14	Class 1.
Do	do	1,200	[a]35.10	Class 2.
Do	do	10,000	[a]26.60	Class 3.
Do	do	3,500	[a]36.60	Class 4.
Huntley	Main canal	900	29.00	Class 1.
Do	do	315	31.00	Class 2.
Do	do	300	33.00	Class 3.

Pavement, excavation, etc.—The specifications for the work mentioned below have no special features that require explanation:

Unit prices for pavement.

Project.	Division.	Amount.	Contract price per square yard.	Remarks.
		Sq. yds.		
Truckee-Carson	Laterals, etc., division 1-2.	4,700	$1.50	
Do	Laterals, etc., division 3-4.	7,400	.50	
Do	Power house, division 6	600	2.00	
Do	Head works	1,000	1.395	
Do	do		1.35	

Unit prices for earth placing.

Project.	Division.	Amount.	Contract price.	Remarks.
		Cu. yds.		
Minidoka	Dam	Rock. 75,000 Earth. 110,000	$0.90 R. .30 E.	(b)
Do	Spillways	Rock. 4,400 Earth. 7,500	.75 R. .50 E.	

[a] Contractor failed.

[b] Maximum layers of 1 foot, thoroughly wet. The bids for overhaul were $0.03, $0.01, and $0.01 per 100 feet, respectively, for the highest, lowest, and lowest total, with a contract price of $0.01. R. and E. stand for rock and earth, respectively.

Unit price for earth excavation, class 1, loose material that can be plowed with four horses.

Project.	Division.	Amount.	Contract price per cubic yard.	Over-haul per 100 feet, contract price per cubic yard.	Remarks.
		Cu. yds.			
Belle Fourche	Main supply canal	800,000	$0.129	$0.01	Total overhaul, 200,000.
Truckee-Carson	Laterals, division 1	150,000	.135	.015	
Do	Laterals, division 2	300,000	.135	.015	
Do	Laterals, division 3	250,000	.14	.02	
Do	Laterals, division 4	400,000	.14	.02	
Do	Old river channel, division 5.	290,000	.15	.01	
Do	Old river channel, division 6.	3,000	.15	----------	
Uncompahgre	South canal, division 1	41,000	.12	.015	
Do	South canal, division 2	22,000	.12	.015	
Do	South canal, divisions 3 and 4.	53,000	.14	.015	
Do	South canal, division 5	24,000	.14	.015	
Do	South canal, division 6	46,000	.11	.05	
Do	South canal, division 7	45,000	.12	.015	
Do	South canal, division 8	48,000	.12	.015	
Do	South canal, division 9	45,000	.12	.015	
Belle Fourche	Dam	18,000	.30	.30	Trenches, class A.
Do	do	6,000	.50	.50	Dam structures.
Do	do	1,580,000	.28	.28	Dam embankments.
Do	do	35,000	.16	.16	Stripping borrow pits.
Do	do	30,000	.30	.30	Trimming dam embankment.
Do	do	230,000	.20	.20	Grading, class A.
Do	Canals	6,000	.15	.15	Stripping borrow pits.
Do	do	351,500	.165	----------	Grading, A.
Do	do	45,000	.165	----------	Excavating from borrow pits.

Unit prices for earth excavation, class 1a; loose material and material that can be plowed with 6 horses.

Project.	Division.	Amount.	Contract price per cubic yard.	Overhaul per 100 feet, contract price per cubic yard.	Remarks.
		Cubic yds.			
Lower Yellowstone.	Division 1, schedule A	1,077,000	$0.14½	$0.01½	
Do	Division 2, schedule A	1,052,000	.14½	.01	
Do	Division 3, schedule A	1,042,000	.129	.01	
Do	Division 4, schedule A	411,000	.12	.01	
Do	Division 1, schedule B	18,000	.24	.01½	
Do	Divisions 2 and 3, schedule B.	7,500	.24	.01½	
Do	Division 4, schedule B	4,500	.25	.02	
Hondo, N. Mex	Diversion dam and inlet canal, schedule 1.	74,000	.12½	.0131	
Do	Outlet canal, schedule 3.	288,000	.12½	.0131	
Do	Embankment, schedule 4	80,000	.12½	.0131	
Do	Embankment, schedule 5	162,000	.14	.0131	
Do	Structures	100	.15	.0131	
Huntley, Mont.	Main canal, division 1	35,000	.23	.02	
Do	Main canal, division 2	305,000	.139	.015	
Do	Main canal, division 3	350,000	.15	.02	
Minidoka	Diversion canal	[a] 16,000 [b] 100	.15	.015	
Do	Canal and foundation of spillways.	48,000	.15	.015	
Truckee-Carson	Distributing system, division 1.	325,000	.15	.01	
Do	Distributing system, divisions 2 and 3.	415,000	.13	.01	
Do	Distributing system, division 4.	185,000	.15	.01	
Do	Distributing system, divisions 5, 6, and 7.	550,000	.12	.01	
Uncompahgre	Cedar Creek portal, approach to tunnel.	75,000	.16	....	

[a] Actual.

[b] Basis for price.

Unit prices for earth excavation, class 1b; all loose material except solid rock and bowlders above 10 cubic feet.

Project.	Division.	Amount.	Contract price per cubic yard.	Overhaul per 100 feet, contract price per cubic yard.	Remarks.
		Cubic yds.			
Salt River	Roosevelt dam	50,000	$1.75	$0.15	
Yuma	Laguna dam	305,000	.30	....	

Unit prices for excavation, class 2; indurated material of all kinds which can not be plowed.

Project.	Division.	Amount.	Contract price per cubic yard.	Over-haul per 100 feet, contract price per cubic yard.	Remarks.
		Cubic yds.			
Belle Fourche	Main supply canal	1,000	$0.25		
Lower Yellowstone.	Division 1, schedule A	1,000	.28		
Do	Division 2, schedule A	1,300	.30		
Do	Division 3, schedule A	1,200	.30		
Do	Division 4, schedule A	800	.30		
Do	Division 1, schedule B	1,500	.34		
Do	Divisions 2 and 3, schedule B.	500	.34		
Do	Division 4, schedule B	200	.40		
Hondo, N. Mex	Diversion dam	200	.46		
Do	Connected with rock work.	100	.46		
Do	On structures	100	.46		
Minidoka, Idaho	Diversion channel	100	.40		
Do	Canal and foundation of spillways.	100	.40		
Uncompahgre	South canal, division 1	8,000	.28		
Do	South canal, division 2	11,073	.28		
Do	South canal, division 3 and 4.	24,000	.25		
Do	South canal, division 5	15,000	.25		
Do	South canal, division 6	6,000	.15		
Do	South canal, division 7 and 8.	10,000	.28		
Do	South canal, division 9	10,000	.28		
Do	Cedar Creek portal	15,000	.23		
Truckee-Carson	Distribution system, divisions 1, 2, 3, 6, 7.	91,223	.25		
Do	Divisions 4 and 5	(a)			
Do	Laterals, ditches, divisions 1 and 2.	900	.45		
Do	Ditches, division 3	(a)	.35		
Do	Ditches, division 4	6,112	.35		
Do	Ditches, division 5	(a)	.25		
Do	Ditches, division 6	(a)	.50		

[a] Amount not stated in contract.

Unit prices for excavation, class 3; loose rock 2 to 10 cubic feet.

Project.	Division.	Amount.	Contract price per cubic yard.	Remarks.
		Cu. yds.		
Truckee-Carson	Distributing system, divisions 1, 2, and 7.	([a])	$0.35	
Do	Distributing system, divisions 3 and 6.	([a])	.35	
Do	Distributing system, divisions 4 and 5.	([a])	.35	
Huntley, Mont	Structures	500	1.00	
Lower Yellowstone	Main canal, division 1, schedule A	1,000	.45	
Do	Main canal, division 2, schedule A	1,200	.30	
Do	Main canal, division 3, schedule A	800	.30	
Do	Main canal, division 4, schedule A	1,200	.30	
Do	Main canal structures, division 1, schedule B.	1,000	.50	
Do	Main canal structures, divisions 2 and 3, schedule B.	500	.50	
Do	Main canal structures, division 4, schedule B.	300	.50	

[a] No amount given.

Unit prices for excavation, class 3a; loose rock up to 20 cubic feet.

Project.	Division.	Amount.	Contract price per cubic yard.	Remarks.
		Cu. yds.		
Huntley, Mont	Main canal, division 1	14,000	$0.60	
Do	Main canal, division 2	100	.80	
Do	Main canal, division 3	100	.30	

Unit prices for excavation, class 3b; loose rock up to 1 cubic yard.

Project.	Division.	Amount.	Contract price per cubic yard.	Remarks.
		Cu. yds.		
Truckee-Carson	Laterals and structures, division 3	....	$0.50	
Do	Laterals and structures, division 4	....	.50	
Uncompahgre	Cedar Creek, portal	5,000	....	
Do	South canal, division 1	2,000	.34	
Do	South canal, division 2	2,000	.34	
Do	South canal, divisions 3 and 4	13,000	.35	
Do	South canal, division 5	7,500	.35	
Do	South canal, division 6	2,000	.50	
Do	South canal, divisions 7 and 8	4,000	.34	
Do	South canal, division 9	5,000	.34	
Belle Fourche	Main supply canal	1,000	.56	
Hondo, N. Mex	Inlet canal and diversion dam, division 1.	100	.65	
Do	Rockwork, division 2	100	.40	
Do	Outlet excavation and embankment, division 3.	100	.65	
Do	Structures, division 6	100	.65	
Minidoka	Diversion channel	1,000	.65	
Do	Canal and foundation of spillways	1,000	.65	

Unit prices for rock excavation, class 4; solid rock requiring drilling and blasting.

Project.	Division.	Amount.	Contract price per cubic yard.	Remarks.
		Cu. yds.		
Truckee-Carson	Laterals, division 3; structures.		$1.25	Quantities not stated.
Do.	Carson reservoir and canal, division 4.		1.25	Do.
Do.	Distributing system, divisions 1-7.		.80	Do.
Yuma, Ariz	Laguna dam	305,000	1.30	
Belle Fourche	Main canal	1,000	1.25	
Huntley	Structures	500	2.00	
Hondo, N. Mex	Reservoir and canals	30,000	.69	
Do.	Structures	100	1.50	
Uncompahgre	South canal, division 1		.95	No quantities stated in contracts.
Do.	South canal, division 2		.95	Do.
Do.	South canal, divisions 3 and 4.			Do.
Do.	South canal, division 5			Do.
Do.	South canal, division 6		1.25	Do.
Do.	South canal, divisions 7 and 8.		.95	Do.
Do.	South canal, division 9		.95	Do.
Do.	Cedar Creek portal cut	25,000	.75	
Minidoka	Diversion channel	47,000	.90	
Do.	Canal and foundation of spillways.	42,000	.70	
Do.	North canal	105,800	.95	
Do.	South canal	65,000	.97	
Salt River	Roosevelt dam	20,000	1.50	
Lower Yellowstone	Main canal, division 1, schedule A.	1,000	.90	
Do.	Main canal, divisions 2 and 4, schedule A.	1,100	.65	
Do.	Main canal, division 3, schedule A.	100	.65	
Do.	Structures, main canal, division 1, schedule B.	1,300	.60	
Do.	Structures, main canal, division 2, schedule B.	10	.60	
Do.	Structures, main canal, division 3, schedule B.	10	.60	
Do.	Structures, main canal, division 4, schedule B.	10	1.50	
Huntley	Main canal, division 1	29,000	1.05	
Do.	Main canal, division 2	100	1.20	
Do.	Main canal, division 3	100	.80	

Unit prices for wet excavation, class 4a.

Project.	Division.	Amount.	Contract price per cubic yard.	Remarks.
		Cu. yds.		
Truckee-Carson	At headworks		$0.75	
Belle Fourche	Main supply canal	3,000	1.50	
Lower Yellowstone	In canal	20,000	.30	Excavation for foundation under water.
Do	At headworks	3,400	1.25	
Do	In canal	20,000	.30	
Huntley	Main canal	20,000	.27	

Unit prices for excavation, solid rock under water or below datum, class 4b.

Project.	Division.	Amount.	Contract price per cubic yard.	Remarks.
		Cu. yds.		
Huntley	Main canal	1,000	$2.50	
Salt River	Roosevelt dam		5.00	

Unit prices for puddling.

Project.	Division.	Amount.	Contract price per cubic yard.	Remarks.
		Cu. yds.		
Lower Yellowstone	Main canal, division 1	1,000	$0.50	
Do	Main canal, divisions 2 and 3.	4,000	.50	
Do	Main canal, division 4	2,000	.50	
Huntley	Structures	500	.50	Around and over concrete structures.
Hondo	Reservoir and canals, division 2.	1,400	.92	Selected material wet to saturation.
Do	Reservoir and canals	100	1.00	Rolled and tamped.
Truckee-Carson	Headworks	1,000	2.00	
Do	Spillway	250	2.00	Around and over structures.
Do	Laterals, etc., divisions 1 and 2.	460	2.00	Selected material wet to saturation; rolled and tamped.
Do	Laterals, division 3	380	.60	
Do	Laterals, division 4	400	.60	
Do	Laterals, division 6	1,000	2.00	

Cost of rations.

Project.	Month.	Rations.	Cost per ration.	Remarks.
	1905.			
Belle Fourche	June	485	$0.45	Construction.
Do	do	769	.42	Survey.
Do	July	508	.39½	Construction.
Do	do	771	455	Survey.
Do	August	513	.565	Construction.
Do	do	584	.50	Survey.
Do	September	430	.61	Construction.
Do	do	493	.54	Survey.
Do	October	456	.426	Construction.
Do	do	416	.558	Survey.
Hondo	April	565	547	
Do	May	230	.73	
Oklahoma	August	440	.617	
Do	September	419	.615	
La Plata	January	(*)	.645	
Do	April	(?)	.45	
North Platte	May	2,400	.80	
Klamath	September	572	.50	
Yuma	August	244	.78	Headquarters.
Do	do	216	.84	Laguna dam.
Do	September	295	.73	Headquarters.
Do	do	290	.66	Survey.
Do	do	287	.72	Laguna dam.
Do	do	45	1.48	Imperial Valley.

Unit prices for telephone.

Project.	Division.	Amount.	Contract price per mile.	Remarks.
		Miles.		
Belle Fourche		16	$254.50	
Minidoka		18	347.50	
Uncompahgre	Section 1	9½	214.11	
Do	Section 2	10	214.80	
Do	Section 3	7½	242.56	
Do	Section 4	1	264.50	
Salt River	Division 1	20	278.00	
Do	Division 2	17	295.00	
Do	Division 3	13	447.00	Iron poles.
Do	Division 4	16	440.00	Do.
Do	Division 5	16	350.00	
Lower Yellowstone	Division 1	35	217.08	
Do	Division 2	35	207.19	

OBSTACLES TO RECLAMATION.

The progress already made in carrying out the terms of the reclamation act has been at all times achieved in the face of obstructions from physical and human agencies, the latter being perhaps the most difficult to overcome.

The physical obstacles are those of lack of water supply, defective foundations, poor material for construction, and soil of doubtful value. Under no one project are all of the conditions good. In some localities there is an excellent reservoir site, but no water; in other places there is a good supply of water, but no place to store it. Again, if there is water the land may be poor, or the canal line may be extremely difficult to construct and dangerous to maintain. All of these things, however, can be overcome in part by careful study.

The human obstacles are more difficult. These consist of defective laws, vested and intangible rights, disinclination to adopt irrigation, and the general desire to give as little as possible for the largest benefits. In some notably exceptional cases individuals and communities have eagerly cooperated with the officials charged with administering the reclamation act. In others there has been apparently a general feeling among the people concerned that money must be spent in their locality and that if they would sit idly back the benefits would be forced upon them.

In the truly arid localities, where men have in good faith attempted to reclaim land and know what irrigation actually means, there has been little delay. On the contrary, in the subhumid localities, where dry farming is usually successful, the obstacles are great. On the one hand, there is a desire on the part of the townspeople and speculators to have Government funds spent in their locality in any kind of work, no matter what the result. The lands to be reclaimed, however, have, as a rule, all been taken up by settlers who are making a fair living by dry farming, and these people, who must ultimately pay the cost of irrigation and must change their whole manner of living in order to practice relatively intensive cultivation of the ground, are not eager to respond to the demands of their fellow citizens to go into the reclamation scheme. Most of them hold back and insist that they shall know all the conditions. Some of them frankly state that they do not want to irrigate and will not willingly risk the savings of a lifetime on this experiment. They want to be let alone and can not see why they should be annoyed or disturbed in the peaceful possession of their farms in order to try what to them seems a rash experiment.

The amount of land in these States which can be irrigated on any considerable scale is very small, in most States less than 1 per cent of the area. The land is now all in the hands of a few persons, and unless these owners are willing to cooperate, to risk their property and to work hard in the future, it is impossible to begin the construction of works under the terms of the reclamation act. The lands are practically monopolized, and the direct benefits can be had only by these few landowners.

SAFETY OF THE RECLAMATION FUND.

The question which is always in the minds of those who are connected with the administration of the reclamation act is that of the future return of the investment. Every possible effort has been made to guard the investment, and experience is demonstrating the fact that the greatest possible skill and forethought must be used. Predictions have freely been made that after the fund is once invested it will not be possible to get back more than a small portion of it, and that the farmers on the reclaimed lands will seek relief.

It has been pointed out again and again that relatively few persons succeed at first on newly irrigated lands, and that under any large development scheme there has been a constant shifting of population during the first few years. Failures and removals may be expected, and it is not believed that under the Government projects the first settlers will all be good farmers or will succeed in making their payments. The law, however, is liberal in this matter, and the advanced value of the land due to the increase of population will unquestionably permit the unsuccessful man to dispose of his holdings at a profit to some one better suited to cope with the conditions.

In view of the many dangers and uncertainties the attempt has been made to draw up the contracts with the water users' associations and with the people in such form that their terms can be enforced in the proper spirit and at the same time to protect the reclamation fund from being diminished.

The demand for the completion of other projects will also act as a spur in the administration of this part of the law, and it is reasonable to expect that the public in general will see to the proper enforcement of the provisions regarding repayment of the fund.

QUARTERLY ESTIMATES.

As the developments under the operations of the reclamation act have been very rapid and the conditions have changed quickly from time to time, it has been deemed wise to make the estimates and secure the approval of the Secretary at shorter periods than is customary in other Government work, and the three-months period or quarter of a year has therefore been adopted as the time unit. Toward the end of each quarter the responsible engineers in the field have been called upon for estimates as to the amount already expended to the end of the last quarter, the amount being expended in the current quarter, and the sums which will be needed during the next quarter, the figures being accompanied by brief statements as to the character of work performed, in hand, and proposed in the near future. These quarterly estimates are assembled in the Washington office as soon as possible after the 15th days of March, June, September, and December. After examination and approval by the chief engineer they are forwarded, in a manuscript report of 100 or more pages, to the Department for approval. The approved estimates form the basis for operations during the succeeding quarter and enable a frequent consideration to be made of the entire plan of work.

In order to illustrate the rapid growth which has taken place during these quarterly periods, the following table is given of the expenditures, by quarters, since the initiation of the work:

Quarter ended—	
(1) September 30, 1902	$20,700.24
(2) December 31, 1902	79,693.78
(3) March 31, 1903	83,065.15
(4) June 30, 1903	102,981.04
(5) September 30, 1903	224,595.29
(6) December 31, 1903	248,695.82
(7) March 31, 1904	340,226.03
(8) June 30, 1904	647,787.87
(9) September 30, 1904	761,701.09
(10) December 31, 1904	973,067.63
(11) March 31, 1905	834,377.88
(12) June 30, 1905	1,145,377.04
(13) September 30, 1905	1,419,605.67
Total	6,881,874.53

In preparing the quarterly estimates the supervising engineers, or the district and constructing engineers under them, are called upon for a brief statement of the location of the work and past operations; also, for a paragraph or more as to present conditions, and next a statement as to future operations. In preparing the figures for the estimates, consideration is first had of the amount originally allotted for the work, based upon the engineers' preliminary estimates. From this amount is deducted the amount already expended and a brief table is given of the liabilities in the form of large contracts partly executed. The balance thus obtained shows the amount of money expendable in the future but for which no legal obligations have been incurred. The estimates for the next quarter thus start with a full knowledge of the principal facts as to expenditures made and balances available.

BUSINESS METHODS.

GENERAL DISCUSSION.

One of the matters of prime importance after the inauguration of surveys, examinations, and construction, has been to devise and put in practice modern business methods as far as these are applicable to governmental affairs. Experience has shown that this is not by any means an easy matter. It is impossible for the officers of the Government to transact public business with the same speed and economy with which they conduct their private affairs. Congress has passed many general laws directing how one detail or another of the business of the Government shall be transacted. Many of these laws are very old; others have been passed without full consideration of the laws then existing, and there are many instances of apparent contradiction.

The Reclamation Service has been injected into a great mass of governmental machinery as a new organization, under a new and unique law, with personnel more or less new to the work and to each other, and with the strong desire of new men to accomplish results. In this desire the employees have been spurred by the reiterated desire of public men and of citizens in general to show results at the earliest possible date. The business methods, therefore, have of necessity been established "in the saddle." It has not been possible to sit down quietly and devise an ideal way of doing things; on the contrary, it has been necessary to plan a system in the midst of the turmoil of creating the service, of starting surveys, of checking plans, and above all of pushing energetically every detail throughout the least settled part of the United States, at localities hundreds of miles apart. In spite of this handicap, the business methods now in effect are believed to be fairly simple and expeditious. Daily care is, however, given to perfecting the details.

BOOKKEEPING.

The system of bookkeeping adopted for the Reclamation Service is satisfactory and embodies only such departures from the ordinary methods as the peculiar needs of the service require.

COST KEEPING.

As construction has advanced on various projects more and more attention has been given to perfecting some thorough system of cost keeping. This is entirely distinct in its methods and results from what is ordinarily termed "bookkeeping," and, although frequently confused with the latter, it should be kept entirely distinct. The bookkeeper has to do with expenditures and with the correct recording of liabilities in such form as to give from day to day the essential facts. The man who is keeping costs, however, must have not merely the principal results obtained by the bookkeeper, but he must have a thorough knowledge of the operations performed and the conditions under which the work was done.

The object to be attained by cost keeping is not simply to know what was paid for a given piece of work; the contract price is usually sufficient for this. If a contractor has been paid 14 cents for moving so many thousand yards of earth, this, in popular opinion, may be considered the cost of the work. It is, however, far from the fact; the actual cost may have been more or less. Nothing is more fallacious than to argue that because certain contracts have been let for a certain amount per yard other contracts should be entered into for a similar amount. It is of prime importance to know not merely what the Government has paid or is paying for certain work, but to have clearly analyzed the actual expenditures by the contractor in accomplishing a certain piece of work under certain conditions. This information, to be of value, can not be obtained by simply taking the total expenditures at the end of the job and dividing it by the number of yards of dirt removed. There must be a daily record of conditions and an analysis of these, taking into account the labor and materials, the investment, the delays, cost of transportation, and a large number of other important factors.

When the construction work of the Reclamation Service was begun, one of the first difficulties encountered was to obtain figures showing accurately the actual cost of various kinds of work. It was possible to obtain general statements that this or that work has been done for so much money; but these statements had little or no value, because little was known of the cost of labor, subsistence, transportation, and the amount of delays incident to labor troubles, floods, and other causes. It was early seen that the accuracy of future estimates rested upon the obtaining of correct figures of costs under the new conditions prevailing in the West, and special efforts were therefore given to initiating the most modern method of cost keeping.

Experience has shown that an exceptionally high class of man, both as an engineer and business man, is required in successful cost keeping on this work. The ordinary engineer does not have a sufficiently analytical mind to grasp all the details, and the successful man at cost keeping is usually found to be the brightest man and the most difficult to keep, as individuals and corporations are continually trying to entice him away, because of his knowledge of actual costs of various classes of work and of the ways in which economies can be successfully introduced. A successful system of cost keeping must include a minute and daily study of every operation, of the arrangement of men, of their supervision, and of the infinite number of details which escape the notice of the ordinary foreman or superintendent. This close analysis leads to the ability to point out where money is being lost by inefficient organization or machinery, and in many instances the Government inspectors on the work under construction have saved contractors from great losses by telling them plainly that their methods or their foremen were inefficient and pointing out the reason, as shown by daily records and observations. Instances might be multiplied where of two subcontractors working side by side and under the same conditions one would be losing money without knowing it and the other making a profit, although the teams and men might be working the same hours and with about the same energy. One man has been handling the material ineffectively with poor tools; the other has been making every stroke count.

One of the fundamental questions which has received careful consideration by the engineers of the Reclamation Service is whether irrigation works can be constructed as economically by the Government as by private parties. Between these two methods of performing such work there are certain differences which are inevitable. Upon the whole, however, it is believed that the ultimate cost of the works constructed by the Reclamation Service will compare favorably with that of works built by private capital.

One essential particular in which the work of the Reclamation Service differs from similar operations conducted by private parties is that the former must be constructed from the beginning with due regard to permanence, whereas private parties, having small funds available, usually build in the first place temporary structures of wood, to be replaced later on when the increase of land values justifies, by works of steel or concrete. While, therefore, the first cost of the works constructed by the Government will be found notably greater than that of works constructed by private enterprise, allowance should be made for the fact that the former embraces a permanent structure, while the latter usually covers a work of temporary character.

OPERATIONS IN ARIZONA.

By LOUIS C. HILL.

SALT RIVER PROJECT.

GENERAL STATEMENT.

On the Salt River project, which was originally selected as the most feasible, work was commenced in October, 1902, by C. R. Olberg, with surveys for a power canal. Cadastral surveys of the lands in Salt River Valley, begun in 1902 by Mr. Robert Muldrow, were completed later by Mr. R. W. Hawley. These surveys have since been extended, and maps covering most of the work have been published.

Preliminary construction work was begun in the summer of 1903, but owing to various causes no contracts were let until the following spring, when construction work on both the power canal and the cement mill was begun.

Very high floods in the summer of 1904 delayed all work, and during the first four months of 1905 floods greater than those of any year since 1891, and far longer in duration, practically suspended all operations. All the railroad bridges over the Salt and Gila rivers save one were washed out from one to ten times, and the road from Mesa to Roosevelt, over which supplies must be hauled, was under water at frequent intervals. Part of the time food and supplies were packed in on burros.

No potable water being available near the Roosevelt dam, it was necessary to pipe water 3 miles from springs in Cottonwood Canyon to two reservoirs, one of 40,000 and one of 20,000 gallons capacity.

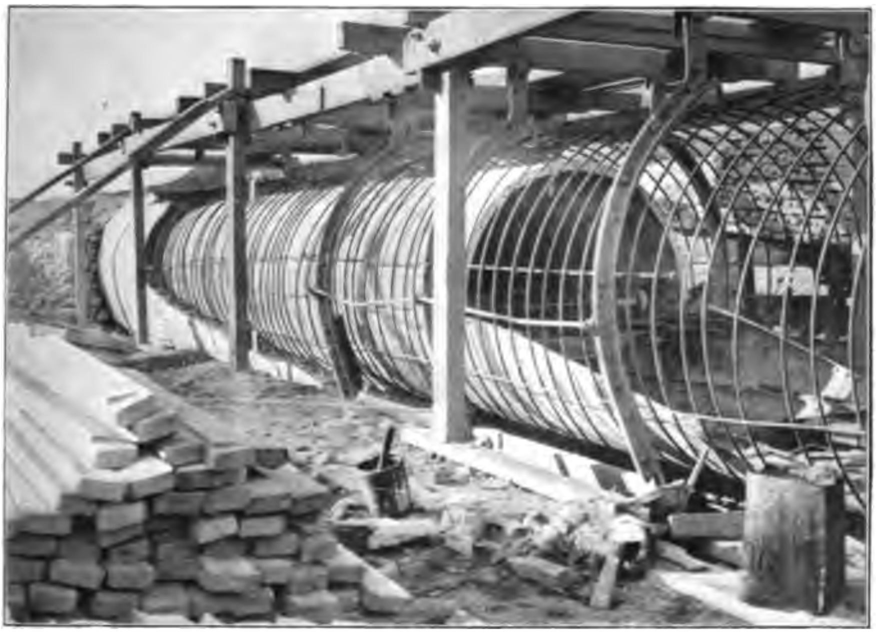
A septic tank sewage system has been in operation for nearly a year. The Government physician, Doctor Palmer, has been made health officer, with absolute power over all camps in this valley. No cases of typhoid fever have developed here in a year, and the health of the entire community has been remarkably good.

The extreme heat of the past summer, lasting almost uninterruptedly from June 1 to October 1, caused many of the men employed in the office to break down. Men in the field, although exposed to the direct rays of the sun, do not seem to suffer in health to the same extent.

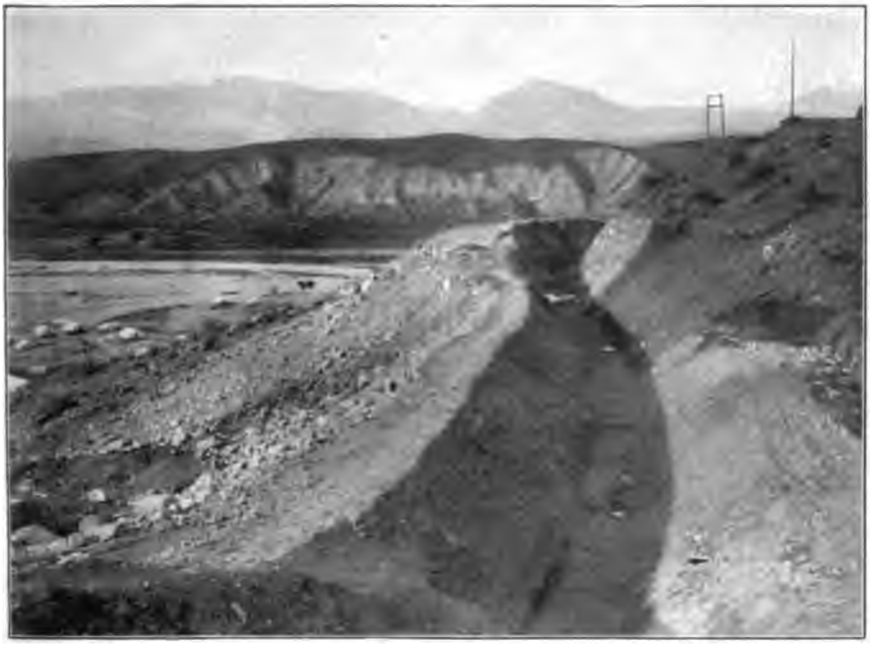
Most of the land within the flood lines of the reservoir has been purchased, but about 15 per cent will probably have to be condemned on account of bad title or excessive price.

POWER CANAL.

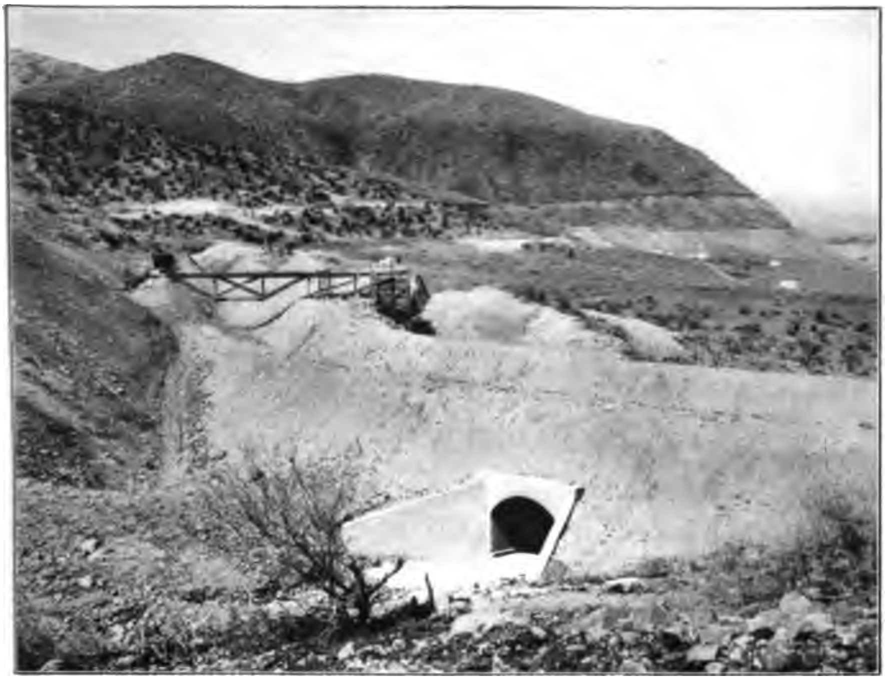
In September, 1903, final location surveys of the power canal were commenced, the work on the upper half of the canal being placed under the immediate charge of O. T. Reedy and the lower portion under A. M. Sprigg. The canal is nearly 19 miles long, and will have a capacity of 200 second-feet. The water will be carried above the reservoir to a point below the dam, and there



A. ALLIGATOR AT LIVINGSTONE FOR PRESSURE PIPE, POWER CANAL, SALT RIVER PROJECT, ARIZONA.

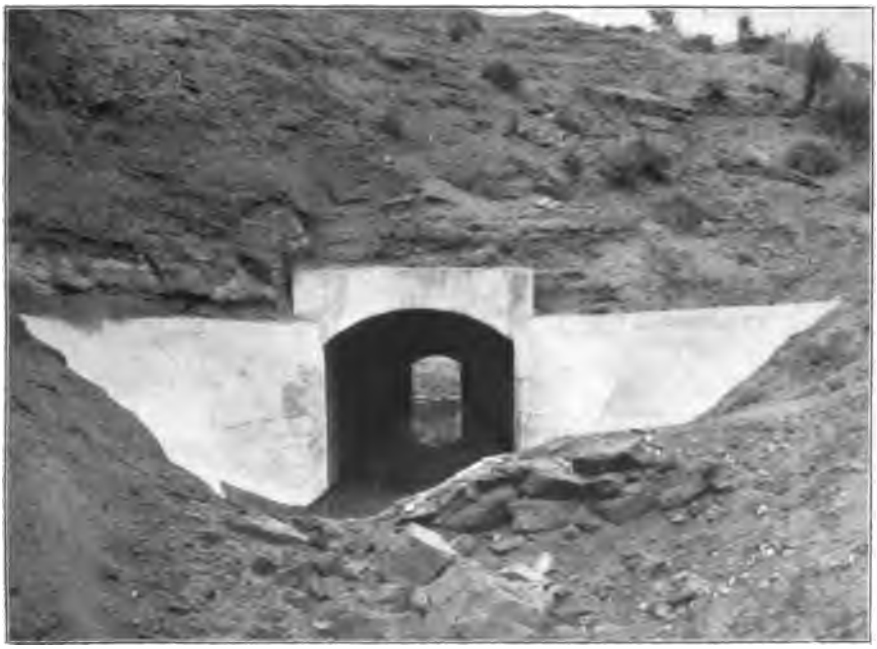


B. COMPLETED PORTION OF POWER CANAL, SALT RIVER PROJECT, ARIZONA.



A. VIEW OF PORTION OF POWER CANAL, SALT RIVER PROJECT, ARIZONA.

Showing completed culvert and high line wagon road.



B. UPPER END OR SOUTH PORTAL OF THE WHERLI TUNNEL ON POWER CANAL, SALT RIVER PROJECT, ARIZONA.

discharged through turbine wheels under an available head of 220 feet, developing 4,400 gross horsepower. The power obtained is to be used in the construction of the dam and in pumping water for irrigation in the Salt River Valley.

A contract was entered into on March 18, 1904, with Robert Sherer & Co., for schedule 1 of the power canal, and with John Tuttle, on March 23, 1904, for schedule 2. Active operations began in April, 1904. These schedules cover the excavation of about 600,000 cubic yards of material and the driving of nearly 9,000 feet of tunnel.

The work has been heavy, and a great amount of cross drainage has to be handled by large culverts and conduits. It was necessary to cross two wide and deep canyons with the power canal, and it was finally decided to use two lines of reenforced concrete pipe, 5 feet 3 inches in diameter, to carry the water under these canyons. The total length of pipe necessary is 6,000 feet, and some of it must operate under a head of 85 feet. This pipe is being built with a machine designed by Mr. F. Teichman, which has proved most satisfactory. From 100 to 150 feet a day can be built under good conditions. The pipe has a longitudinal and circumferential reenforcement of five-eights-inch rods spaced at suitable intervals to resist the pressure. (See Pl. IV, *A*.)

The head works of the power canal consist of a concrete diversion dam, with sluicing gates, and an intake tunnel with regulating gates. The intake tunnel and gates and that portion of the dam containing the sluicing gates are finished. These structures were designed by Mr. A. L. Harris.

To carry the water from the power canal to the water wheels an inclined penstock tunnel 620 feet long has been driven from the power house to the canal. The lower portion of the tunnel is lined with steel backed with concrete, and the upper portion is lined with concrete. Gates at the head of the penstock and overflow weirs enable the discharge to be controlled without endangering the canal.

Views along the power canal are shown on Pls. IV, *B*, and V, and detailed plans are given on Pl. VI.

SAND-CRUSHING PLANT.

After numerous experiments had been made to test the strength of cement mortars made with sand from various banks near the dam and with sand made by crushing dolomite limestone the superior strength of mortar made from the latter material became so apparent that it was decided to open a quarry and put in a sand-crushing plant. Accordingly plans were drawn and specifications made for a plant capable of producing in eight hours 60 yards of sand so crushed that it all will pass a one-fourth-inch mesh screen.

The bid of the Mine and Smelter Supply Company, of El Paso, Tex., amounting to $5,531.81, was accepted, and on June 28, 1905, the contract was signed.

The machinery is all on the ground, the foundations are built, and work on the building is nearly completed. This plant will be run by the 150-kilowatt generator that now furnishes power to the cement mill. The plant has been so designed that it will require but one man to operate it.

CEMENT MILL.

The machinery for the cement mill has been installed and the works were ready to start the manufacture of cement by March, 1905. Storms, however.

prevented the delivery of fuel oil until the middle of April. The kiln was started on April 21, and since that date all the cement used for culverts, for pipe, and for lining the power canal has been made by the government mill at a considerable saving in cost, and with satisfactory results.

About 19,000 barrels of cement have been made and used in this way by operating the mill with electric power produced by a generator driven by a steam engine—a temporary expedient adopted until the power canal could be completed, when the power will be produced by a generator driven by a water wheel, at a nominal cost. Then the output of the cement plant will be increased to its full capacity—350 barrels daily.

The cement works are located on a hillside, where the limestone deposit is found. The site is 2,500 feet upstream from the dam site, and the lowest floor is 300 feet above the present level of Salt River and about 30 feet above the high-water line of the reservoir, thus being free from danger of flooding.

The mill building covers an area of 150 feet square and is built in terraces similar to those of stamp mills, the lowest floor being 60 feet below the highest. The building is built of structural iron trusses, supported by wooden columns, and the galvanized corrugated-iron roofing is laid on wood purlins. On the highest terrace are bins for the storage of limestone and clay, into which those materials are dumped from cars hoisted by electric-driven hoisting drums. From the rock bin the limestone is delivered to a No. 4 Gates crusher, which spouts the crushed rock to a Smidth automatic feeder that regulates the feed to a rotary drier below. From the drier the limestone is elevated to a storage bin above a ball mill; from the ball mill the crushed, dried, and ground rock is delivered to a bin. The clay goes through a similar process and is stored in a bin alongside the ground-rock bin. The materials are mixed at this point and conveyed to a pebble mill, and from that mill to a reenforced concrete storage bin in the rear of the kilns. Automatic feeders deliver the raw mixture from the storage bin to rotary kilns, where it is burned to a semivitrified condition called clinker. The clinker is delivered by the kilns to a rotary cooler, and this cools and conveys it to a bucket elevator that spouts it into a vertical tower for storage, preparatory to grinding in ball and pebble mills. After grinding, an elevator delivers the cement to a troughed belt conveyer that conveys it to any of a number of storage bins located from 50 to 100 feet away. Some of the machinery in the cement plant is shown on Pl. VII.

Approximately three parts of limestone are mixed with one of clay in making cement. The limestone is quarried within a few hundred feet of the mill and the clay used is hauled a mile and a half. Mr. H. A. Tobleman, chemist at the mill, gives the approximate composition of the materials, as follows:

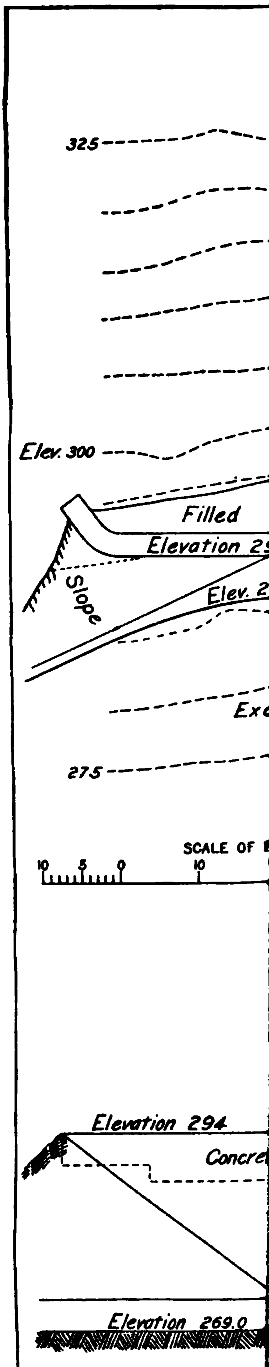
Analyses of cement-making material and cement made at Salt River project, Arizona.

[Per cent.]

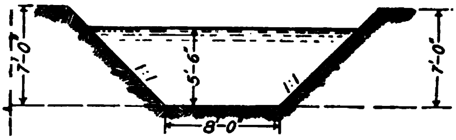
	Silica.	Ferric oxide.	Alumina.	Carbonate of lime.	Carbonate of magnesia.	Sulphur compound.
Limestone	3.00	0.15	0,35	96.00	0.35	0
Clay	50.00	5.00	17.50	15.00	9.50	0
Raw mixture	14.50	1.40	4.60	75.50	3.60	0
Cement	22.63	2.53	7.00	[a]64.50	[b]2.80	0

[a] Lime.

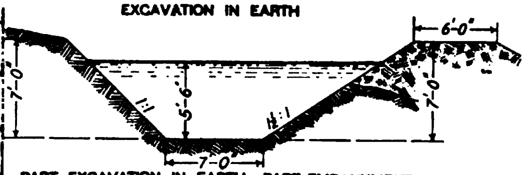
[b] Magnesia.



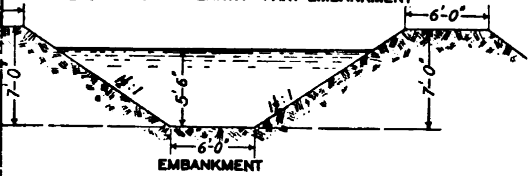
SECTIONS OF CANAL



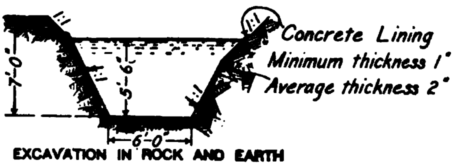
EXCAVATION IN EARTH



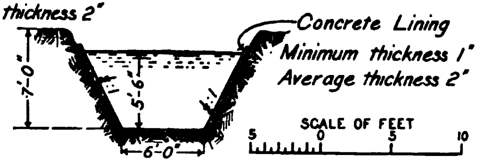
PART EXCAVATION IN EARTH PART EMBANKMENT



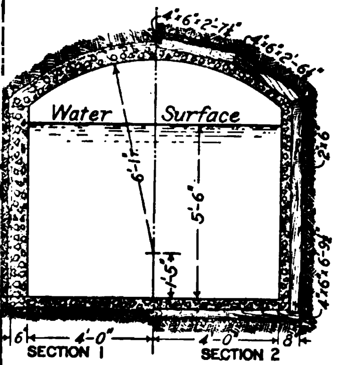
EMBANKMENT



EXCAVATION IN ROCK AND EARTH

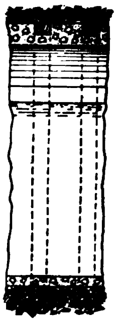


EXCAVATION IN ROCK



SECTION 1
TUNNEL IN EARTH
THAT WILL STAND
UNTIL LINED

SECTION 2
TUNNEL IN EARTH
THAT WILL NOT STAND
UNTIL LINED



LONGL. SECTION

SCALE OF FEET

0 1 2 3 4 5 6 7 8

Mr. J. Y. Jewett, cement expert, made the following report on a fair sample of the cement: Soundness, O. K.; fineness, 95 per cent passing No. 100 sieve and 70 per cent passing No. 200 sieve; initial setting time, 7½ hours; final setting time, 12 hours; average of three tensile tests neat cement briquettes, in 7 days 510 pounds and in 28 days 561 pounds; average of tests of three briquettes made of 1 sand to 3 cement, 7 days 264 pounds and 28 days 341 pounds.

The laboratory tests of the cement have demonstrated the superior quality of the raw and finished materials, and the use of the cement in the construction of the power canal during the last six months has enabled the engineers to observe with satisfaction the action of the cement in actual use.

The fuel used to burn the cement is California crude petroleum. Eleven gallons are required to burn a barrel of cement. The contract for this oil was let to C. R. Eager & Co., of Los Angeles, at a price of $3.48 per barrel delivered at the cement mill, in quantities of 3,000 barrels monthly. The oil is hauled by rail from California to Mesa, Ariz., thence by traction engine 24 miles and by mule teams 37 miles to Roosevelt.

Bids for fuel oil, Salt River project.

Name.	Address.	Oil, per barrel.				Hauling, Mesa to Roosevelt.		Hauling, Globe to Roosevelt.	
		Price.	Delivered at—	Delivered at Mesa.	Delivered at Roosevelt.	Per barrel.	Per ton (2,000 pounds).	Per barrel.	Per ton (2,000 pounds).
O. S. Stapley & Co.	Mesa, Ariz					$2.59	$15.00		
Associated Oil Co.	San Francisco, Cal.	$0.25	Oil City	$1.25	$4.35				
Edward Malley	do				4.49	3.22	18.50		
John Tuttle						2.24½	15.00		
Union Oil Co	Los Angeles, Cal.	.199	Bakersfield						
Wm. S. Miller	San Francisco, Cal.	.25	Wait, Kern County.						
E. B. & A. L. Stone Co.	Oakland, Cal	.27½	East construction spur, Kern oil fields.			2.49	18.00		
Old Dominion Com. Co.	Globe, Ariz							$2.43	$13.00
C. R. Eager & Co.	Los Angeles, Cal.				3.48		14.40		
Ed Cox	San Francisco, Cal.					2.26	17.00		
Wolf Sachs	Tempe, Ariz					2.24½ [a]13.80	13.60		

[a] Per ton.

ROOSEVELT DAM.[a]

This dam will be located in the canyon of Salt River, just below the mouth of Tonto Creek, and will impound about 1,300,000 acre-feet of water. Two spillways, each about 200 feet long, carry the flood waters around the dam. A roadway is carried over the dam, crossing the spillways on concrete steel-arch bridges. The general dimensions of the dam are as follows:

Dimensions of Roosevelt dam.

	Feet.
Height of spillway above datum, or mean low water	220
Height of roadway above datum, or mean low water	240
Total height of the dam from lowest point of foundation to top of parapet, about	280
Length of dam at datum	210
Width of roadway	16
Width at base, about	170

Masonry to be used in structure, about 340,000 cubic yards.

The specifications require the building of a masonry dam constructed of broken range cyclopean rubble laid so as to break joints and thoroughly bonded in all directions. The stone will be quarried from the walls on each side of the canyon and from the spillways and will be laid in cement mortar. That for the upstream face will be selected so as to lie with horizontal beds and vertical joints in Portland cement mortar, composed of one part Portland cement and two parts sand.

It is contemplated that the work shall be carried on continuously day and night until the dam has reached the height of 150 feet. The electricity for lighting will be furnished free by the United States, and power will be furnished the contractor at a low rate from the temporary power plant.

The dam is built on a curve having a radius of about 400 feet. This dam will back the water up Salt River about 16 miles and up the Tonto nearly as far. It will produce a lake somewhat over 25 miles long and from 1 to 2 miles wide. The reservoir will have a capacity greater than that of any other artificial reservoir in the world.

The general specifications for the construction of this dam are similar to those provided for other work. The detail specifications were printed in full in the Third Annual Report of the Reclamation Service, pages 147 to 151.

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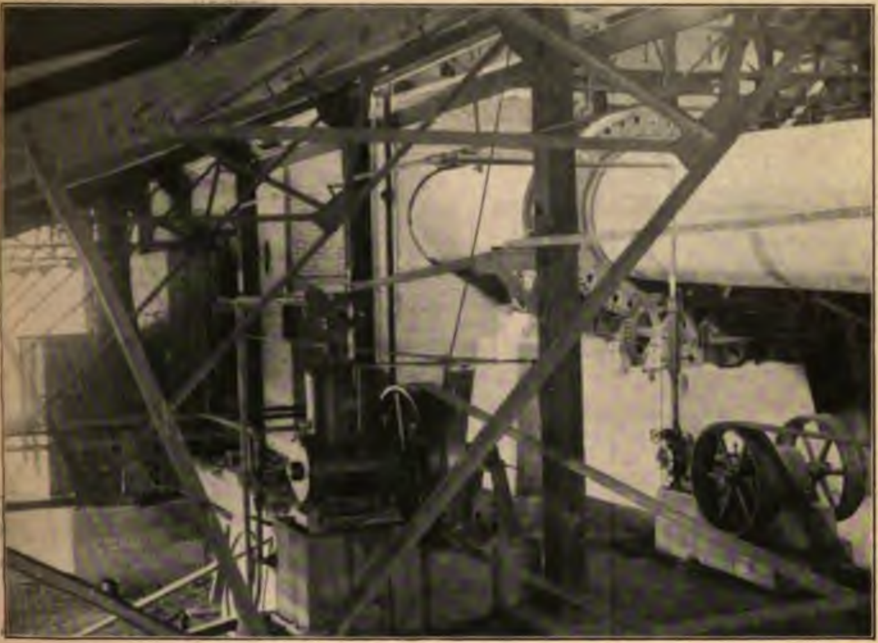
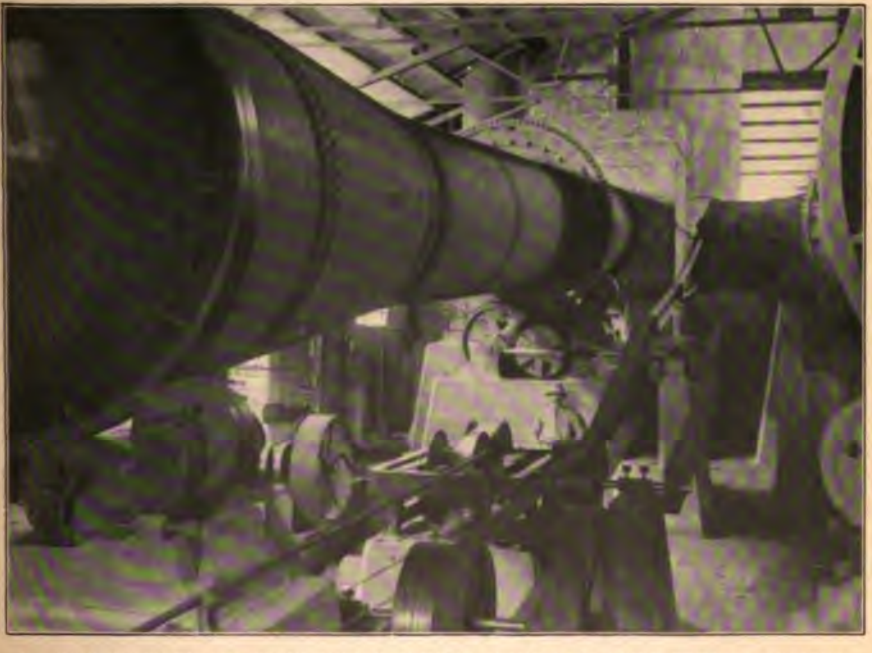
[a] See Pl. IX, Third Annual Report Reclamation Service, 2d edition.



A. BOILER, ENGINE, AND COMPRESSOR IN CEMENT PLANT, SALT RIVER PROJECT, ARIZONA.



B. VIEW BETWEEN THE KILNS UNDER CEMENT PLANT, SALT RIVER PROJECT, ARIZONA.

Bids for construction of Roosevelt dam.

Bidders.	Time.	Excavation for foundation.					
		Class 1, 50,000 cubic yards.		Class 2, 6,000 cubic yards.		Class 3, 20,000 cubic yards.	
		Price per yard.	Amount.	Price per yard.	Amount.	Price per yard.	Amount.
John M. O'Rourke & Co., Galveston, Tex.	2 years	$1.75	$87,500	$5.00	$30,000	$1.50	$30,000
Broderick & Ward, St. Louis, Mo.	17 months	[a] .96	48,000	3.50	21,000	2.75	55,000
Geddis & Seerie Stone Co., Denver, Colo.	33 months	2.00	100,000	4.00	24,000	1.00	20,000
Edward Malley & Co., San Francisco, Cal.	26 months	2.50	125,000	7.00	42,000	3.00	60,000
Carl Leonardt, Los Angeles, Cal.	23 months	2.30	115,000	1.50	9,000	1.50	30,000
Mason Hoge Co., Frankfort, Ky.	3 years	1.65	82,500	2.60	15,600	2.60	52,000
MacArthur Brothers Co., Chicago, Ill.	33 months	1.75	87,500	3.50	21,000	2.50	50,000
Griffiths & McDermott, Chicago, Ill.	30 months	2.25	112,500	4.00	24,000	2.00	40,000
Deeks & Deeks, St. Paul, Minn.	2½ years	4.00	200,000	8.00	48,000	1.25	25,000
E. B. & A. L. Stone Co., Oakland, Cal.	40 months	5.00	250,000	10.00	60,000	2.00	40,000
Mosier De Graff Contracting Co., Buffalo, N. Y.	2 years 6 months.	2.50	125,000	3.50	21,000	1.50	30,000
Winters-Parsons & Boomer, Spokane, Wash.	2½ years	5.40	270,000	8.00	48,000	1.25	25,000
San Francisco Bridge Co., San Francisco, Cal.	35 months	2.50	125,000	5.00	30,000	3.00	60,000
Johnson-Sherman Construction Co., Oklahoma City, Okla.	27 months	.75	37,500	6.50	39,000	3.40	68,000
Bentley-Tuttle & Pelton Co., San Francisco, Cal.	28 months	3.70	185,000	7.50	45,000	4.15	83,000
Pendergast & Clarkson, Chicago, Ill.	700 days	2.85	142,500	7.00	42,000	2.35	47,000
Faris-Kels Construction Co. (Limited), Boise, Idaho.	2 years	3.35	167,500	5.25	31,500	2.50	50,000
The American Construction Co., Denver, Colo.	3 years' continuous work.	1.50	75,000	3.00	18,000	2.50	50,000
B. M. Zadeck Co., Chicago, Ill.	2 years 6 months.	7.50	375,000	8.30	49,800	2.00	40,000
R. H. Hood Co., New York, N. Y.[a]	21,000 working hours.	....	....	....	....	3.00	....
Bentley-Tuttle & Pelton Co., San Francisco, Cal.[a]	23 months	3.70	185,000	7.50	45,000	4.15	83,000
Burrell Construction Co., Oakland, Cal.[a]	3 years	3.00	150,000	6.00	36,000	2.00	40,000

[a] Informal.

Bids for construction of Roosevelt dam—Continued.

Bidders.	Time.	Masonry.					
		Dam, 300,000 cubic yards.		Coping, 400 cubic yards.		Wing walls, 6,000 cubic yards.	
		Price per yard.	Amount.	Price per yard.	Amount.	Price per yard.	Amount.
John M. O'Rourke & Co., Galveston, Tex.	2 years	$3.15	$945,000	$20.00	$8,000	$4.75	$28,500
Broderick & Ward, St. Louis, Mo.	17 months	3.10	930,000	15.00	6,000	15.00	90,000
Geddis & Seerie Stone Co., Denver, Colo.	33 months	3.35	1,005,000	10.00	4,000	4.00	24,000
Edward Malley & Co., San Francisco, Cal.	26 months	3.25	975,000	8.00	3,200	3.00	18,000
Carl Leonardt, Los Angeles, Cal.	23 months	3.45	1,035,000	24.00	9,600	3.45	20,700
Mason Hoge Co., Frankfort, Ky.	3 years	3.49	1,047,000	6.25	2,500	4.13	24,780
MacArthur Brothers Co., Chicago, Ill.	33 months	3.70	1,110,000	20.00	8,000	7.00	42,000
Griffiths & McDermott, Chicago, Ill.	30 months	3.80	1,140,000	6.50	2,600	3.25	19,500
Deeks & Deeks, St. Paul, Minn.	2¼ years	3.50	1,050,000	10.00	4,000	4.00	24,000
E. B. & A. L. Stone Co., Oakland, Cal.	40 months	3.25	975,000	30.00	12,000	7.50	45,000
Mosier De Graff Contracting Co., Buffalo, N. Y.	2 years 6 months.	3.85	1,155,000	25.00	10,000	3.85	23,100
Winters-Parsons & Boomer, Spokane, Wash.	2¼ years	3.50	1,050,000	10.00	4,000	4.00	24,000
San Francisco Bridge Co., San Francisco, Cal.	35 months	4.11	1,233,000	10.00	4,000	5.00	30,000
Johnson-Sherman Construction Co., Oklahoma City, Okla.	27 months	4.71	1,413,000	10.50	4,200	4.40	26,400
Bentley-Tuttle & Pelton Co., San Francisco, Cal.	28 months	5.05	1,515,000	8.00	3,200	5.50	33,000
Pendergast & Clarkson, Chicago, Ill.	700 days	5.25	1,575,000	20.00	8,000	8.00	48,000
Faris-Kels Construction Co. (Limited), Boise, Idaho.	2 years	5.40	1,620,000	15.00	6,000	7.50	45,000
The American Construction Co., Denver, Colo.	3 years' continuous work.	7.40	2,220,000	12.00	4,800	8.75	52,500
B. M. Zadeck Co., Chicago, Ill.	2 years 6 months.	7.17	2,151,000	25.00	10,000	6.55	39,300
R. H. Hood Co., New York, N. Y.[a]	21,000 working hours.	3.35	....	10.00	....	4.50	....
Bentley-Tuttle & Pelton Co., San Francisco, Cal.[a]	23 months	4.94	1,482,000	8.00	3,200	5.50	33,000
Burrell Construction Co., Oakland, Cal.[a]	3 years	3.90	1,170,000	6.00	2,400	3.90	23,400

[a] Informal

Bids for construction of Roosevelt dam—Continued.

Bidders.	Time.	Concrete.				Over-haul.	Total.
		2 bridges.		4 bridge piers, 600 cubic yards.		In excess of 300 feet.	
		Price each.	Amount.	Price per yard.	Amount.	Price per cubic yard.	
John M. O'Rourke & Co., Galveston, Tex.	2 years	$7,500.00	$15,000	$6.00	$3,600	$0.15	$1,147,600.00
Broderick & Ward, St. Louis, Mo.	17 months	16,500.00	33,000	7.00	4,200	.05	1,187,200.00
Geddis & Seerie Stone Co., Denver, Colo.	33 months	5,500.00	11,000	4.00	2,400	.05	1,190,400.00
Edward Malley & Co., San Francisco, Cal.	26 months	4,000.00	8,000	5.00	3,000	.05	1,234,200.00
Carl Leonardt, Los Angeles, Cal.	23 months	6,500.00	13,000	5.50	3,300	.10	1,285,600.00
Mason Hoge Co., Frankfort, Ky.	3 years	6,000.00	11,000	5.00	3,000	.01½	1,239,380.00
MacArthur Brothers Co., Chicago, Ill.	33 months	5,000.00	10,000	6.00	3,600	.02	1,332,100.00
Griffiths & McDermott, Chicago, Ill.	30 months	2,575.00	5,150	3.40	2,040	.02	1,345,790.00
Deeks & Deeks, St. Paul, Minn.	2½ years	6,000.00	12,000	8.00	4,800	.03½	1,367,800.00
E. B. & A. L. Stone Co., Oakland, Cal.	40 months	5,500.00	11,000	8.00	4,800	.05	1,397,800.00
Mosier De Graff Contracting Co., Buffalo, N. Y.	2 years 6 months.	14,300.00	28,600	12.00	7,200	.20	1,399,900.00
Winters-Parsons & Boomer, Spokane, Wash.	2½ years	4,000.00	8,000	4.00	2,400	.01½	1,431,400.00
San Francisco Bridge Co., San Francisco, Cal.	35 months	5,000.00	10,000	4.00	2,400	.03	1,494,400.00
Johnson-Sherman Construction Co., Oklahoma City, Okla.	27 months	4,600.00	9,200	7.40	4,440	.07	1,601,740.00
Bentley-Tuttle & Pelton Co., San Francisco, Cal.	28 months	6,000.00	12,000	5.50	3,300	.02½	1,879,500.00
Pendergast & Clarkson, Chicago, Ill.	700 days	15,000.00	30,000	6.00	3,600	.07½	1,896,100.00
Faris-Kels Construction Co. (Limited), Boise, Idaho.	2 years	14,000.00	28,000	6.00	3,600	.10	1,951,600.00
The American Construction Co., Denver, Colo.	3 years' continuous work.	10,000.00	20,000	7.50	4,500	.08	2,444,800.00
B. M. Zadeck Co., Chicago, Ill.	2 years 6 months.	8,300.00	16,600	7.00	4,200	.20	2,685,900.00
R. H. Hood Co., New York, N. Y.[a]	21,000 working hours.	7,000.00	14,000	6.00	....	.04	....
Bentley-Tuttle & Pelton Co., San Francisco, Cal.[a]	23 months	6,000.00	12,000	5.50	3,300	.02½	1,846,500.00
Burrell Construction Co., Oakland, Cal.[a]	3 years	5,000.00	10,000	4.00	2,400	.03	1,434,200.00

[a] Informal.

The contract was awarded to John M. O'Rourke & Co., of Galveston, Tex., and was signed by the Secretary of the Interior on April 8, 1905.

The operations of the contractors so far consist in the building of a camp along the most improved and sanitary lines, including a concrete reservoir for water supply and accompanying roads and trails for access to the work; hauling in and assembling their machinery; putting in anchorages for the cableways which are to span the work; starting to strip the quarries which are to furnish stone for the dam, and driving piles for the upper temporary dam, which is to protect the work while it is in its earlier stages, in the bottom of the canyon.

In order to take full advantage of the electric power which is to be furnished to them at a low price by the Government, it was necessary for the contractors to equip with electric machinery throughout, and quick deliveries could not be obtained.

Two Lidgerwood cableways, 1,200 feet in length, with fixed anchorages outside each spillway, will pass the stone and mortar to the dam, where the setting will be done with derricks furnished by the American Hoist and Derrick Company.

An air compressor will be installed to run the drills in the quarries.

An aerial tramway, 1,700 feet long, will take the cement from the Government cement mill and deliver it at the contractors' stone crusher and concrete-mixing plant, near the south end of the dam. This tramway will also handle the sand, which is to be crushed limestone, from the quarry and crushing plant operated by the Government midway between the cement mill and the dam.

For the purpose of excavating the sand and gravel in the river bed at the dam site, it is proposed to install two 11-inch hydraulic gravel elevators, with giants to wash the material to them. As auxiliaries, and for the purpose of keeping the pit free from water later, there will be installed four hydraulic water lifts. The water to operate this installation will be furnished from the power canal under a head, in the bottom of the pit, of about 250 feet.

It was the intention, in designing the cofferdams and flume, to provide structures that would safely withstand any flood liable to be encountered, even if the pit were flooded, in which case it would only be necessary to pump out the water and silt in order to resume work when the flood had passed. The manner in which the piles thus far have been driven seems to indicate that no great difficulty will be encountered in carrying out the plans as designed.

No expense has been spared by the contractors in acquiring a perfectly adequate plant, and it may be confidently expected that the work will be satisfactory as regards both quality and rate of progress. The construction of the dam will be under the direct supervision of Mr. C. W. Smith, constructing engineer.

TELEPHONE LINE.

On December 26, 1903, a contract was entered into with James R. Thorpe, of Denver, Colo., for the construction of a telephone line from the head of the power canal to the Arizona dam, 25 miles from Phoenix. Later this line was extended by force account into Phoenix and Mesa, and the local service was greatly improved. At Phoenix the line connects with the Consolidated Telephone Company's system, connecting through it with the principal towns in the Territory. The line will ultimately connect with all the pumping plants in the valley, and will be invaluable in the future operations of the whole irrigation system of the Salt River Valley.

DRAFTING.

The work of designing this project, estimating its cost, and drawing the plans has mostly been done on the ground by the draftsmen in the office of the supervising engineer.

The period from July 1 to December 31, 1903, was taken up in making reconnoissance maps for roads and regular topographic sheets, in preparing layouts and estimates for the power canal, and in drawing designs of sections and structures to accompany the contract for the canal.

ROADS.

The nearest town, Globe, is 40 miles away, and it was necessary to build nearly 20 miles of road to connect it with the dam site. This work was completed in February, 1904. The road from Roosevelt to Mesa has been open for traffic about ten months. During September an account was kept which showed 1,517,000 pounds of freight passed over it during that month.

The road to the timber in the Sierra Ancha has also opened up a new country. Gila County and the inhabitants of Pleasant Valley are extending this road to that valley, where it will connect with the road to Holbrook.

Altogether it has been necessary to construct about 110 miles of road, part of which replaces roads that will be flooded by the reservoir. Later about 10 miles more must be added to replace a road up Tonto Creek, which will fall within the confines of the reservoir.

Freight is a great item in the expense of this project. It forms 30 per cent of the cost of the more expensive machinery. The cost of fire brick at the kiln forms but 10 per cent of the cost at Roosevelt, and the cost of oil at the fields but 7 per cent. The remaining 90 to 93 per cent goes to pay railroad and wagon freight.

SAWMILL AND LUMBER.

Since the beginning of construction on the Salt River project the engineers of the Reclamation Service have cut from the public lands in the neighboring mountains and sawed with a Government mill about 3,000,000 board feet of lumber and about 1,100 poles and piles, of lengths from 25 to 40 feet, for use on telephone and other electric lines and for temporary works at Roosevelt dam. A large part of this lumber has been used in timbering tunnels on the power canal, for concrete forms, and for buildings, bridges, repairs, etc., on the work. The balance is stored in the yards at Roosevelt, to be drawn upon as needed. Only an insignificant amount of lumber has been brought in from outside for use on this project.

The lumber cut is a pine resembling the common Oregon pine of lumber yards. Its quality is good, though not quite equal to that of Oregon pine. It is found at an elevation of about 6,000 feet and over.

The hauling has been done by teams over a distance varying from 28 to 32 miles. For this purpose about 23 miles of mountain road were built.

Had the lumber necessary for the construction of this project been purchased in the nearest markets the cost must necessarily have been much greater, as the lowest prices in the nearest lumber yards, located at Globe and Mesa, approximate close to the cost for which it has been laid down in Roosevelt from the Government mill, thus saving at least the item of wagon freight over a distance of from 40 to 60 miles. It has also been of considerable advantage to be able to cut unusual and special bills of timber on short notice.

The first million feet was sawed under two contracts, in which the contractors cut the logs and sawed them, with the Government mill, into sizes ordered and piled the lumber at the contract price per thousand feet board measure. The mill was kept in repair by the Government. Both of these contracts, however, turned out unsatisfactorily. Both from lack of experience in handling contracts and from difficulty in obtaining skilled help in running the machinery the contractors were never able to turn out lumber to the reasonable capacity of the mill. Inexperience and the tendency to handle the machinery recklessly because of the Government's guaranty to keep it up led to many breakdowns and vexatious delays in repairing. The isolated location of this region from cities and shops renders it very difficult to get any kind of careful metal or machine work done, often making it necessary to send hundreds and even thousands of miles to replace or repair a broken part.

After sawing about a million feet of lumber the contractor threw up the contract, and it was found necessary to put an entire new crew on Government pay rolls. The results have been entirely satisfactory. After sawing 2,000,000 feet of lumber it has been found that the cost is less than when done under contract and the rate of output has been more than doubled, without serious breakdowns.

Logging is done with heavy low-wheeled trucks. Snow in these mountains can not be depended upon to assist in the work of logging.

The sawmill has been operated under the management of Mr. A. L. Harris, assistant engineer.

HYDRAULIC GATES, ROOSEVELT DAM.[a]

A tunnel about 500 feet long has been driven through the side walls of the canyon at the dam. In this tunnel will be placed six gates to be used for sluicing purposes and for regulating the flow of water to the canals in the Salt River Valley, about 50 miles below. These gates, with their operating mechanism, etc., will weigh nearly 800,000 pounds, and will be the largest ever constructed to operate under the great pressure of 100 pounds per square inch. The pressure on each gate is about 800,000 pounds. With the reservoir full, these gates are capable of discharging 10,000 cubic feet per second. During the construction of the dam the river will be diverted through this tunnel.

The plans and specifications for the construction of these gates were prepared under the direction of the project board of engineers, by F. Teichman. Bids were opened on October 1 at Denver, and the contract was awarded to the Llewellyn Iron Works, of Los Angeles.

POWER PLANT.

A permanent power plant is being built at the foot of the dam to contain hydraulic and electric machinery for utilizing both the energy from the power canal and that stored in the water in the reservoir.

It is contemplated that the water in the reservoir will be drawn down to the 80-foot level through pipes connecting with water wheels. The power so developed will be transmitted from 50 to 70 miles to Salt River Valley and there used for operating centrifugal pumps. These pumping plants will be distributed over the valley at locations that will furnish the largest supply of water and best serve the requirements. With the water at its present horizon each horsepower developed at the dam will furnish power sufficient to pump water to irrigate nearly 10 acres in the valley 60 miles away.

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[a] See Pls. VII and VIII, Third Annual Report Reclamation Service, 2d edition.

Bids were opened in Los Angeles on November 1 and 2 for furnishing one or more 1,260-horsepower water wheels and one or more 750-kilowatt three-phase dynamos, to be added to the present equipment of one 1,300-horsepower water wheel and one 950-kilowatt dynamo already installed in the power house. An abstract of the bids (p. 76) follows:

Bids received for hydraulic apparatus, power plant, Salt River project, Arizona.

Item.		S. Morgan Smith, York, Pa.	Allis-Chalmers Co., Milwaukee, Wis.	Camden Iron Works, Camden, N. J.	Risdon Iron Works, San Francisco, f. o. b. San Francisco, except governor.	I. P. Morris Co., Philadelphia.	Platt Iron Works, Dayton, Ohio.	Pelton Water Wheel Co., San Francisco, f. o. b. San Francisco.	Lombard Governor Co.	Replogle Governor Co.
1	Generator wheel	$2,780.00	$3,019.00	$4,500.00	$5,200.00	$6,350.00	$6,784.00	$7,200.00		
2	Generator wheel governor	$1,225.00	$1,183.00		$1,250.00	$2,000.00	$1,025.00	$825.00	$1,200.00	
2a	Generator wheel governor				$1,400.00	$3,000.00	$1,200.00	$1,150.00		
3	Exciter wheel	$875.00	$1,298.00	$1,840.00	$2,500.00	$1,800.00	$900.00	$1,360.00		
4	Exciter wheel governor	$275.00	$650.00		$300.00	$285.00	$250.00	$350.00		$400.00
5	4-foot gate valve, hydraulically operated	$1,400.00	$1,500.00	$1,450.00	$3,800.00	$635.00	$2,000.00	$2,000.00		
5a	4-foot gate valve, mechanically operated	$1,150.00	$1,350.00	$1,650.00	$3.500.00	$725.00	$1,600.00	$2,000.00		
6	3 18-inch gate valves, each	$110.00	$325.00	$300.00	$750.00	$75.00	$175.00	$175.00		
7	18-inch pipe fittings	$210.00	$450.00	$380.00	$250.00	$185.00	$156.00	$125.00		
8	2 relief valves, each	$630.00	$403.00		a $1,400.00	$1,090.00	$625.00	$360.00	$625.00	
9	2 generator wheels, each	$2,780.00	$3,019.00	$7,250.00	a $10,400.00	$5,200.00	$6,184.00	$6,975.00		
10	2 generator wheel governors, each	$1,225.00	$1,183.00		a $2,500.00	$1,785.00	$1,025.00	$825.00	$1,200.00	
10a	2 generator wheel governors, each		b $2,835.00		a $2,800.00	$2,075.00	$1,200.00	$1,150.00		
11	2 4-foot gate valves, hydraulically operated, each	$1,400.00	$1,500.00	$1,450.00	a $6,500.00	$635.00	$1,900.00	$1,900.00		
11a	2 4-foot gate valves, mechanically operated, each	$1,150.00	$1,350.00	$1,650.00	a $6,900.00	$725.00	$1,600.00	$1,900.00		
	Time of delivery	4 months.	7 months.	4 months.	4 months.	5 months.	120 days.	4 months.	3 months.	90 days.
	Weight, generator wheel and case, pounds	36,985	29,200		50,000	40,000		47,500		
	Weight, exciter wheel and case, pounds	7,742	10,600		15,000	6,000		11,000		
	Price, items 1, 3, and 9, f. o. b.	$9,215.00	$10,350.00	$13,590.00	$18,100.00	$18,550.00	$20,052.00	$21,310.00		
	Weight, items 1, 3, and 9	118,517	98,200		165,000	126,000		153,500		
	Freight, items 1, 3, and 9, to Roosevelt, Ariz	$2,940.00	$2,450.00		$2,780.00	$3,160.00		$2,560.00		
	Cost, items 1, 3, and 9, delivered	$12,155.00	$12,800.00		$20,880.00	$21,700.00		$23,870.00		
	Price, necessary auxiliaries, f. o. b. c	$9,950.00	$10.981.00		$23,000.00	$10,350.00	$11,056.00	$9,995.00		

Efficiency generator wheel, full gate[d]	81	79	80	76	....	78.5	....	....	....
Efficiency generator wheel, three-fourths gate[d]	81	81	76	78	82	80	....	....	....
Efficiency generator wheel, one-half gate[d]	80	77	....	78	70	75	....	....	....
Efficiency exciter wheel, full gate[d]	81	....	80	75	....	....	....	....	....
Efficiency exciter wheel, three-fourths gate[d]	81	....	76	77	80	....	....	....	....
Efficiency exciter wheel, one-half gate[d]	80	....	....	72	....	....	....	....	....

[a] Total.
[b] Including oil tank and pump to supply set governors
[c] Includes items 2, 4, 5, 6, 7, 8, 10, and 11.
[d] These efficiencies are the average per cent between the points named.

Bids received for electrical apparatus, Salt River project, Arizona.

Work or material.	California Electrical Works, San Francisco, Cal. (Western Electrical Apparatus, Chicago.) f. o. b. Chicago, Ill.[a]	Westinghouse, Pittsburg, Pa.	General Electric, Schenectady, N. Y.	Crocker Wheeler, New York City, N. Y.	Allis-Chalmers Co., Milwaukee, Wis.	Hendrie Bolthoff, Denver, Colo.[b]	Warren Electric, Sandusky, Ohio.[c]
One generator, item 1	$5,400.00	$6,600.00	$7,763.00	$7,280.00	$7,252.00	$8,030.00	$9.900.00
One exciter, item 2	$1,485.00	$1,950.00	$1,658.00	$1,788.00	$1,720.00	$1,595.00	$2,000.00
One switch board, item 3	$887.00	$860.00	$834.00	$1,130.00	$801.00	$1,032.00	$2,100.00
Two generators, later delivery, item 4	$10,800.00	$13,200.00	$13,977.00	$14,560.00	$14,504.00	$16,050.00	$19,000.00
One exciter, later delivery, item 5	$1,485.00	$1,950.00	$1,658.00	$1,788.00	$1,720.00	$1,595.00	$2,000.00
Two generators, later delivery, item 6	$5,400.00	$6,600.00	$6,631.00	$7,280.00	$6,710.00	$8,030.00	$10,000.00
Delivery of items 1, 2, and 3	6 months.	6½ months.	5½ months.	210 days.	6 months.	5 months.	
Shipping weight of generator, in pounds	43,700	50,000	37,500	40,000	68,000		55,000
Shipping weight of exciter, in pounds		9,500	9,500	10,000	14,000		10,000
Freight rate (Government) to Roosevelt, Ariz., 100 pounds	$2.08	$2.10	$2.10	$2.10	$2.05	$2.00	$2.10
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Efficiency generator, at 100 per cent power factor, 125 per cent load	95.0					95.0	95.0
Efficiency generator, at 100 per cent power factor, full load	95.0	94.0	95.0	95.0	95.0		95.5
Efficiency generator, at 100 per cent power factor, ¾ load	94.0	92.7	94.0	94.0	94.0	94.0	93.0
Efficiency generator, at 100 per cent power factor, ½ load	91.5	90.0	92.0	92.0	92.0	92.5	91.0
Regulation of generator, at 100 per cent power factor	8.0	8.0	8.0	8.0	8.0	7.0	6.0
Regulation of generator, at 90 per cent power factor		14.0	15.0	16.0	16.0	15.0	11.0
Regulation of generator, at 85 per cent power factor	19.0		18.0				11.5
Regulation of generator, at 80 per cent power factor		18.0	22.0	18.0	21.0	20.0	12.0
Regulation of generator, at 70 per cent power factor	25.0	20.0	28.0	20.0	24.0	23.0	18.5
Price, items 1, 2, and 3, f. o. b.	$7,772.00	$9,410.00	$10,255.00	$10,198.00	$9,773.00	$10,717.00	$14,000.00
Freight, items 1, 2, and 3	$1,127.00	$1,270.00	$1,008.00	$1,070.00	$1,701.00		$1,870.00
Cost, items 1, 2, and 3, delivered	$8,900.00	$10,680.00	$11,263.00	$11,268.00	$11,474.00		$15,870.00

Weight in pounds, items 1, 2, and 3	54,200	60,500	48,000	51,000	83,000	....	66,000
Price, items 1, 2, 3, 4, and 5, f. o. b	$20,057.00	$24,560.00	$25,890.00	$26,546.00	$25,997.00	$28,374.00	$35,000.00
Freight, items 1, 2, 3, 4, and 5	$3,145.00	$3,570.00	$2,783.00	$2,960.00	$4,779.00	....	$3,870.00
Cost, items 1, 2, 3, 4, and 5, delivered	$23,202.00	$28,130.00	$28,673.00	$29,506.00	$30,776.00	....	$38,870.00
Weight in pounds, items 1, 2, 3, 4, and 5	151,000	170,000	132,500	141,000	238,000	....	186,000
Price, items 1, 2, 3, 4, 5, and 6 (2 generators), f. o. b	$30,857.00	$37,760.00	$39,152.00	$41,106.00	$39,417.00	$44,432.00	$55,000.00
Freight, items 1, 2, 3, 4, 5, and 6 (2 generators)	$4,963.00	$5,690.00	$4,358.00	$4,640.00	$7,568.00	....	$6,200.00
Cost, items 1, 2, 3, 4, 5, and 6 (2 generators), delivered	$35,820.00	$43,450.00	$43,510.00	$45,746.00	$46,985.00	....	$61,200.00
Weight in pounds, items 1, 2, 3, 4, 5, and 6 (2 generators)	238,500	270,000	207,000	221,000	369,000	....	296,000

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[a] Authorized signature on bid received November 4, 1905.

[b] Manufacturer not named. Weights not given.

[c] No certified check with bid.

UNDERGROUND WATER OF SALT RIVER VALLEY.

It is intended to utilize the power developed at the dam, both from the reservoir and the power canal, for pumping the underground waters of the Salt River Valley. This water will be used for irrigating in the district not covered by canals. If sufficient water can be developed, it is proposed to construct additional power plants along the river, so as to utilize all the available water for irrigation.

The underground water conditions are described in the Third Annual Report, second edition, pages 152–154, and in Water-Supply Paper 136.

VERDE RIVER RESERVOIR.

The waters of Verde River enter Salt River just above the head of the Arizona canal. The waters of this stream are much fresher than the Salt and the flow in the river is but slightly less.

The complete utilization for irrigation of all the water flowing in Salt and Verde rivers would require a reservoir on each stream and pumping plants to conserve the underground waters of the valley. To get the best results from this water it will be necessary to have a complete system of distributing canals and laterals, so laid out and constructed as to reduce seepage and evaporation to a minimum.

Surveys for a power plant to utilize the waters of the Verde have been made by J. D. Stannard and estimates of its cost are being made.

EXPENDITURES.

The total expenditures on the Salt River project to September 30, 1905, are as follows:

Expenditures on Salt River project to September 30, 1905.

Work.	Contractor.	Amount.	
Power canal:			
Excavations	Shearer & Co	$187,024.17	
Tunnels	John Tuttle	166,623.66	
Pressure pipe and lining canal.	Force account	92,614.13	$446,261.96
Power plant tunnel	do		31,208.63
Power plant (temporary and permanent):			
Construction and operation	do	88,244.46	
Water wheels	Stillwell-Bierce & Smith-Vaile Co	5,000.00	
Generators	Bullock Electric Manufacturing Co	9,687.50	102,931.96
Sluicing tunnel:			
Excavation	John Tuttle	11,178.00	
Approaches	Force account	9,982.00	
Gates	Llewellyn Iron Works	2,668.80	23,828.80
Cement plant:			
Construction of foundations, etc., and operation.	Force account	170,648.15	
Building	Wilcox & Rose	12,505.56	
Machinery	Allis-Chalmers Co	38,880.00	
Motors	Hendrie-Bolthoff Manufacturing Co.	10,641.50	
Storage bin	Force account	8,000.00	
Fuel oil	C. R. Eager & Co	5,912.79	246,588.00
Waterworks	Force account		11,185.81
Refrigerating plant	do		5,069.83
Machine and blacksmith shops and corrals.	do		20,000.00
Office building and cottages	do		22,484.00
Hospital, construction and maintenance.	do		8,677.97
Roads	do		327,615.69
Telephone lines	J. R. Thorpe	22,711.43	
Do	Force account	18,426.52	41,137.95
Purchase of lands		39,725.00	
Purchase of rights of way		40,100.00	79,825.00
Machinery		10,000.00	
Lumber		20,000.00	
Fuel	J. E. Sturgeon	5,032.60	
Subsistence and miscellaneous camp expenses.		31,428.25	
Freighting	Wolf Sachs	4,407.37	
Do	Miscellaneous	62,500.00	133,368.22
Preliminary examination			61,912.92
Gaging streams			8,094.55
Engineering and inspection			16,490.20
Administration			79,000.00
Total			1,654,620.99

gable lands was necessary in order that maps might be made upon which a distribution system could be outlined before final locations were made. The work of mapping the region was begun in April, 1905. The work was under the direction of Mr. T. H. Humpherys, project engineer; Mr. D. L. Reaburn, topographer, having immediate charge. The area surveyed was mapped on a scale of 2,000 feet to the inch, with contour intervals of 2½, 5, and 10 feet, depending upon the general character of the slopes. The area mapped included the irrigable lands of the project, together with the beds of Lower Klamath and Tule lakes. This survey was connected with the general triangulation system of the Coast and Geodetic Survey. The elevations reduced to sea level datum were obtained by a line of levels carried into the basin from the United States Geological Survey bench mark at Thrall, Cal.

MAIN CANAL.

Final location of the main canal from the head of Link River to near Olene, a distance of about 10 miles, has been made, and plans and specifications for its construction have been prepared. These plans and specifications were approved by a board of engineers consisting of Messrs. Newell, Wisner, Lippincott, Jacobs, and Humpherys, which convened at Klamath Falls on August 5, 1905.

This main canal is designed to carry 1,500 second-feet of water, having a maximum velocity of 2.27 feet per second, and will supply the upper portion of Klamath Valley east of the Klamath River. The headgates for this main canal will be built of concrete, fitted with steel gates. The gate, six in number, are each 5 by 11 feet, and are designed to carry a maximum head of 19 feet. Hand power will be used for operating the gates.

In the location of the main canal careful consideration was given to the advisability of carrying the canal around the hill on the line of the Ankeny canal or through the hills by a tunnel. The first route would involve the construction of a portion of the canal through the town of Klamath Falls. It was believed by the board of engineers that the construction of an open channel carrying a swift current of water through the settled portions of the town should be avoided, and that the tunnel line possessed other advantages in economy of maintenance.

TUNNEL LINE.

The tunnel is 3,100 feet long and has a cross-sectional area of 148.5 square feet. It is designed for a maximum velocity of 10.1 feet per second. The canal at the approaches to the tunnel, where the cutting is deep, is of contracted section and, together with the tunnel, is to be lined with concrete to withstand the high velocities. Diamond-drill investigations on the line of the tunnel show that the material is principally a deposit of soft lava ash of such quality as to permit economical tunnel construction.

The Klamath Falls Irrigating Company's (Ankeny) canal line for the first mile of its course, along Link River, is available for use as a power canal in connection with the construction of the tunnel line and for purposes of generating power for pumping. Below this point the Ankeny canal will be enlarged and used for several miles.

KENO CUT.

Drilling operations have been carried on over a considerable area at the head of the rapids below Keno to determine the most economical location for the Keno cut. Three possible plans for the lowering of the river at this point are being considered; first, a tunnel or open cut through the hill direct, a distance of about 3,800 feet; second, an open cut around the base of the hill along the left bank of the river, and third, the project of dredging the channel of the river. Drilling investigations show that the hill is composed almost entirely of hard rock, and the present indications are that the plan for an open cut along the base of the hill will be found the most economical. This matter can not be definitely settled, however, until careful estimates of the cost of construction on each of the lines named have been completed.

DIAMOND-DRILL WORK.

In addition to those made on the line of the main canal for head works and tunnel investigations and at Keno, borings to determine bed-rock conditions have been made at the Clear Lake dam site and are now under way at the Horse Fly dam site. These investigations show that conditions at the Clear Lake site are favorable, bed rock having been found at a depth of about 6 feet below the surface of the stream.

The work on the Horse Fly dam site is not yet sufficiently advanced to report definitely on bed-rock conditions. The work so far as done, however, shows that the conditions are not so favorable as at the Clear Lake dam site.

POWER POSSIBILITIES.

Investigations have been made of the possibilities of developing power to be used for pumping water to some of the higher levels. At the first branch of the main canal, about 10 miles below Klamath Falls, there is a drop of 25 feet. The water available for the development of power at this drop is 1,140 second-feet. The preparation of plans for utilizing this power for pumping has been taken up by Mr. O. H. Ensign, electrical engineer. The water will be pumped from Lost River at Olene.

In April, 1905, filings on the waters of the Klamath River at the rapids below Keno were made by officers of the Reclamation Service pending investigations of the stream. It is believed that sufficient power may be developed at this point to permit the irrigation, by pumping, of considerable areas above the reach of gravity canals. The public lands along Klamath River below Keno have been withdrawn from entry.

PURCHASE OF PRIVATE IRRIGATION SYSTEMS.

Agreements for the purchase of the works of the Klamath Canal Company, the Little Klamath Water Ditch Company, and the Klamath Falls Irrigating Company have been entered into between the officers of the Reclamation Service and the companies. These agreements have been approved by the Secretary of the Interior and abstracts of title and deeds of conveyance preparatory to the transfer of the properties to the United States are now being prepared. A tentative agreement has been entered into whereby the United States is to acquire control of the Moore Brothers' canal, on the west side of Link River. This canal has been used by the Moore Brothers for diverting water for irrigation and power purposes for the past twenty-five years. By the terms of this agreement they are to surrender their canal right of way and all riparian and other vested rights to the waters of Link River and are to receive therefor water for power purposes to the amount of 205 second-feet when actually required.

CLEAR LAKE RESERVOIR SITE.

An agreement for the purchase of the lands for the Clear Lake reservoir site has been approved by the Secretary of the Interior. This purchase includes all the lands bordering on the lake which are below the upper contour of the reservoir, and carries with it a quitclaim of all rights to the bed of said lake and a waiver of all riparian and other rights connected therewith. The contract also contains a waiver of all claims to riparian rights to Tule Lake. The necessary abstract and deed of conveyance for the transfer of the property are now being prepared.

EXAMINATION OF SOILS.

A thorough examination of the soil and water supply of the project has been made. The soil survey shows that the land is in nearly all places of such character as to insure satisfactory results when properly drained and cultivated. Some differences of opinion exist as to the amount of the lake beds which may be brought under cultivation, and it is planned to make further investigations on this question. All of the uplands of the project are reported to be quite free from alkali. The water conditions of the valley are reported favorable.

Observations on Tule Lake indicate that this lake, which has no surface outlet, may have an underground outlet. Evaporation records which have been carefully kept at Keno indicate an annual loss by evaporation of about 38 inches. The records of rainfall, inflow, and variations in the surface of the lake indicate a loss from its surface of about 60 inches. Another and no less important factor which tends to confirm the theory that an underground passage exists is that Tule Lake is fresh water, despite the fact that no surface outlet exists. The formation of the country is volcanic in its nature, and the rocks exposed show great fissures. The country to the southwest is well supplied with springs, a fact which also tends to show that underground channels may exist.

WATER SUPPLY.

Gagings of the streams tributary to the lands of the project have been maintained since preliminary investigations were begun. The results of these measurements confirm former conclusions that the water supply is sufficient. On the upper project, however, it may be that stored water must be held over from wet years for those that are dry. This can be done with the reservoir capacity available.

Measurements on Link River, which is the outlet of Upper Klamath Lake, show that the normal flow of that stream is sufficient for the lower project. To supply any deficiency which might occur, and to provide for the 205 second-feet to be delivered to Moore Brothers, Upper Klamath Lake could be used as a storage reservoir. The grade of the main canal is such that the lake can be drawn down about 3 feet below the low-water stage on a dry year. The raising of the waters of this lake is not now contemplated. Should it in future be decided to take water from the Klamath River into the Shasta Valley, it is believed that the amount required can be stored by constructing a low weir at the outlet of the upper lake. It is desirable that the waters of the lake shall not be raised more than is necessary, in order to protect from overflow, as far as possible, the large areas of swamp lands in this upper lake country.

Gaging stations are now maintained on the following streams:

Link River at Klamath Falls, Oreg.
Klamath River at Keno, Oreg.
Lost River at Clear Lake dam site.
Lost River at Merrill, Oreg.
Miller Creek at Horse Fly dam site.
Sprague River, 5 miles below Yainax, Oreg.

Following are estimated discharges at the principal stations for 1904–5. The season of 1904–5 was one of exceptional drought. During the winter of 1903–4 it is estimated that 658,000 acre-feet were discharged into Tule Lake. Of this amount it is probable that not less than 40 per cent, or 275,000 acre-feet, passed the Clear Lake dam site, and not less than 30 per cent, or 206,400 acre-feet, passed the Horse Fly dam site.

Estimated discharge of Link River at Klamath Falls, 1904–5.

Month.	Mean monthly discharge.	Total monthly discharge.
1904.	*Sec.-feet.*	*Acre-feet.*
May [a]	8,640	291,330
June	6,740	401,058
July	4,123	253,513
August	2,336	143,635
September	1,662	98,895
October	1,686	103,668
November	1,837	109,309
December	2,185	134,350
1905.		
January	2,624	161,343
February	3,103	172,332
March	3,087	189,812
April	3,106	184,819
May	2,597	159,683
June	2,004	119,246
July	1,363	83,806
August	1,051	64,624

[a] Last 17 days.

Estimated discharge of Lost River at Merrill, Oreg., 1904–5.

Month.	Mean monthly discharge.	Total monthly discharge.
1904.	*Sec.-feet.*	*Acre-feet.*
July (last 6 days)	203	2,415
August	199	12,236
September	165	9,818
October	158	9,715
November	150	8,926
December	150	9,223
1905.		
January	248	15,249
February	514	28,546
March	461	28,346
April	470	27,967
May	150	9,223
June	138	8,212
July	125	7,686
August	125	7,686

Estimated discharge of Miller Creek at Horse Fly dam site, 1904–5.

Month.	Mean monthly discharge.	Total monthly discharge.
1904.	*Sec.-feet.*	*Acre-feet.*
August	1.30	79
September	.20	12
October	2.40	148
November	3.70	221
December	6.20	381
1905.		
January	179.0	11,006
February	138.0	7,664
March	153.0	9,408
April	71.0	4,225
May	6.5	400
June	3.0	179
July	.0	0
August	.0	0

Estimated discharge of Lost River at Clear Lake, near Tule Lake, Oreg., 1904–5.

Month.	Mean monthly discharge.	Total monthly discharge.
1904.	*Sec.-feet.*	*Acre-feet.*
September	11.3	673
October	18.1	1,113
November	15.5	923
December	18.2	1,119
1905.		
January	120.0	7,379
February	217.0	12,052
March	224.0	13,773
April	127.0	7,557
May	14.6	898
June	21.6	1,286
July	[a]7.0	430
August	[a]6.0	369

[a] Mean flow for July and August estimated.

Estimated discharge of Klamath River at Keno, Oreg., 1904–5.

Month.	Mean monthly discharge.	Total monthly discharge.
1904.	*Sec.-feet.*	*Acre-feet.*
June	7,076	421,051
July	4,177	256,834
August	2,513	154,518
September	1,778	105,798
October	1,775	109,141
November	2,007	119,425
December	2,235	137,425
1905.		
January	2,716	167,000
February	3,096	171,886
March	3,052	187,660
April	3,097	184,284
May	2,688	165,278
June	2,157	128,350
July	1,436	88,297
August	1,065	65,485

WATER USERS' ASSOCIATION.

The Klamath Water Users' Association was organized March 4, 1905, and is regularly incorporated under the laws of the State of Oregon, with a capital stock of $2,000,000.

As set forth in its articles of incorporation, "one of the enterprises in which the association proposes to engage is to aid and assist the Reclamation Service of the United States in carrying on projects for irrigating and reclaiming lands of the shareholders of this corporation; to drain, dike, reclaim, and render fit for agricultural and other purposes swamp and marsh lands and overflowed lands covered by water belonging to shareholders of this corporation; to enter into any agreement with the proper representative of the United States with reference to the collection and payment of any and all charges made under the Federal statutes for the works providing water for the lands of its shareholders; to comply with the provisions of any Federal statutes applicable to the work done by the United States in connection with such system of water supply, and any rules and regulations established thereunder; to perform any and all acts necessary or appropriate for the accomplishment of any of the said purposes or anything incident thereto."

The assignment of the lands of the project has been taken up by the Water Users' Association and 95 per cent of all the lands under the lower project have been subscribed under the terms of the reclamation act. These assignments provide for the disposal of all holdings in excess of 160 acres, which has been fixed as the maximum area for which water may be obtained by any one person.

PRESENT OPERATIONS.

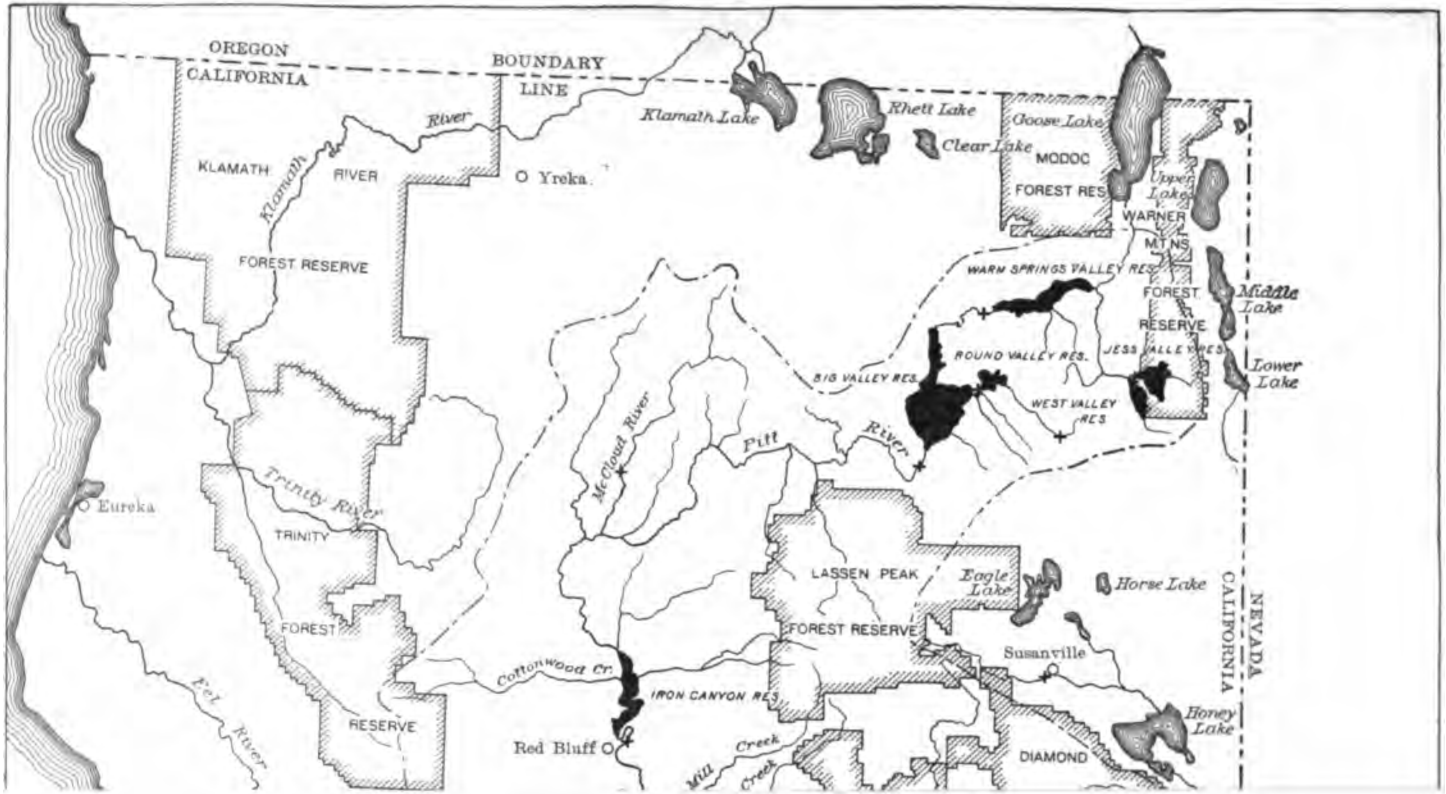
The work of the project is being planned at present with a view to beginning construction at an early date. The lower project has been selected as the one which should be first constructed for three reasons; first, the necessity for water in order to properly maintain the present development of the country and provide for future growth is greater on the lower project; second, the water supply of the lower project is assured, and, third, contracts to a greater extent have been signed by private landowners under the lower project. It is expected that by the time work can be begun on the upper project sufficient data on that water supply will be at hand to enable the engineers to provide for more economical methods of conserving and distributing these waters than is at present possible.

The cost of concrete construction in the Klamath basin at present is high, due to the lack of railway facilities. It is believed, however, from present indications, that this condition will be improved within a short time, as two railways are now being projected into the basin. The McCloud River Railway Company is now engaged on actual construction on a line said to have its terminus on Lower Klamath Lake, and it is stated that connections from this point will be made for the present with Klamath Falls by steamer. The Weed Railway Company is also providing for the construction of a line directly to Klamath Falls. About 25 miles of this road has been built, and the remaining portion is being located. Both of these lines are planned to connect with the main line of the Southern Pacific Company.

The present plans for the head works of the main canal at the head of Link River provide for permanent work of steel and concrete, and it is believed that the importance of these works justifies such construction. Before final plans are made for the remaining and less important structures, however, a comparison will be made of the estimated costs of permanent structures under present conditions and with improved transportation facilities, and should the difference be sufficient to warrant it, temporary structures will be considered for first construction.

SACRAMENTO VALLEY PROJECTS.

Investigations on Sacramento Valley projects have been continued during the season of 1904–5. These investigations include a general study of the water supply and the location and survey of available reservoir sites. The Sacramento Valley proper (Pl. VIII) contains about 4,196 square miles and the total area of its basin, including its mountainous portions, is 26,187 square miles. The water supply is ample for irrigating the entire valley, if properly controlled. The mean run-off from the watershed of the Sacramento River at Iron Canyon, 4 miles above Red Bluff, for the months of January to April, inclusive, the four months of greatest discharge, is 55 per cent of the mean annual flow. The discharge from May to September, inclusive, the five months when there will be the greatest need of water for irrigation, is less than 24 per cent of the total mean annual flow. In working out this project these facts show the necessity of storing the flood flow for use during the irrigation season, since sufficient water must be left in the river during that period for the purposes of navigation. The following reservoir sites have been surveyed: Guenoc and Monticello, on Puta Creek; Clear Lake and Little Indian Valley, on Cache Creek; Briscoe, East Park, and Mill Site, on Stony Creek; Iron Canyon on Sacramento River; Jess Valley and West Valley, on South Fork Pit River; Warm Spring Valley, and Big Valley on Pit River; Round Valley on Ash Creek; Big Meadows on North Fork of Feather River; Indian Valley on Indian Creek. A summary of the data concerning these reservoirs is as follows:


OREGON
CALIFORNIA
BOUNDARY LINE
Klamath Lake
Rhett Lake
Clear Lake
Goose Lake
MODOC FOREST RES.
Upper Lake
WARNER MTNS.
FOREST RESERVE
Middle Lake
Lower Lake
NEVADA
CALIFORNIA
KLAMATH RIVER FOREST RESERVE
Klamath River
O Yreka
Eureka
TRINITY FOREST RESERVE
Trinity River
Eel River
WARM SPRINGS VALLEY RES.
ROUND VALLEY RES.
JESS VALLEY RES.
BIG VALLEY RES.
WEST VALLEY RES.
McCloud River
Pitt River
LASSEN PEAK FOREST RESERVE
Eagle Lake
Horse Lake
Susanville
Honey Lake
DIAMOND
Cottonwood Cr.
IRON CANYON RES.
Red Bluff
Mill Creek
Creek

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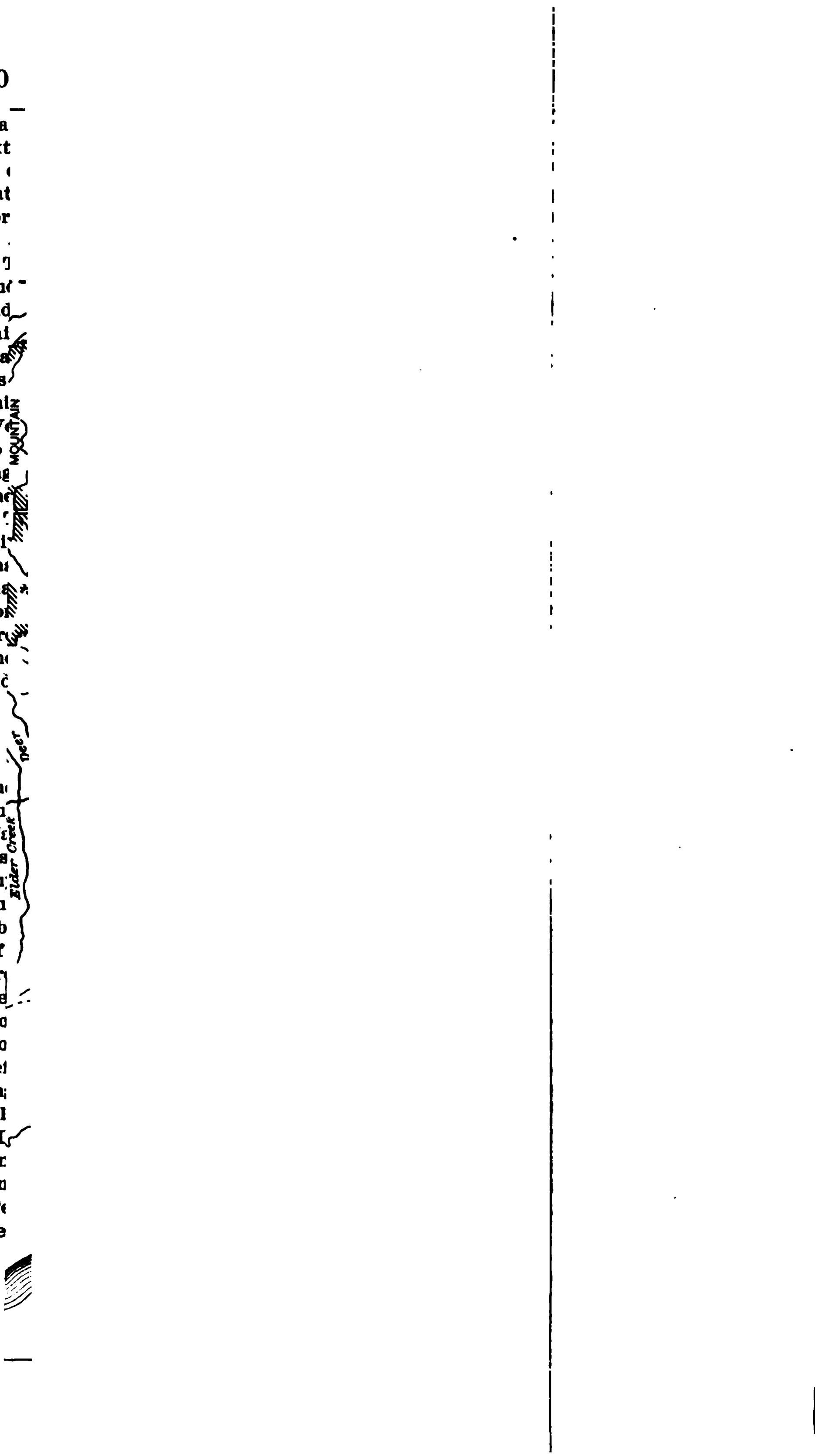

Capacity of reservoirs surveyed in Sacramento basin.

Name of reservoir.	Description.	Capacity of reservoir basin as surveyed.	Probable amount available annually from watershed.
		Acre-feet.	*Acre-feet.*
Guenoc	100-foot loose rock-fill dam with wasteway	188,000	80,000
Monticello	Greatest depth of water 150 feet. Proper height of dam not yet determined.	130,000	130,000+
Clear Lake	16-foot dam. Outlet channel	100,000	100,000
Little Indian Valley	130-foot concrete overflow dam	76,500	50,000
Briscoe	125-foot concrete gravity dam with wasteway	14,385	14,385
East Park	115-foot concrete gravity dam with wasteway	26,000	26,000
Mill Site	95-foot loose rock-fill dam with wasteway	43,735	43,735
Iron Canyon	170-foot rubble concrete dam with wasteway	226,900	226,900+
Jess Valley	60-foot loose rock-fill dam with wasteway	224,560	
West Valley	70-foot loose rock-fill dam with wasteway	94,579	
Warm Spring Valley	do	559,015	
Big Valley[a]	100-foot concrete overflow dam	3,196,188	[b]1,000,000
Round Valley	70-foot loose rock-fill dam, with wasteway	184,732	
Big Meadows	West arm: Greatest depth of water, 40 feet. Proper height of dam not yet determined.	227,880	500,000
	East arm: Greatest depth of water, 80 feet	246,500	
Indian Valley	Greatest depth of water, 110 feet	688,000	500,000
Total		6,226,974	2,671,020

[a] Big Valley reservoir site is below Jess Valley, West Valley, Warm Spring Valley, and Round Valley reservoir sites.

[b] This estimate includes discharge from Goose Lake drainage.

A survey is now in progress of Mohawk and Grizzly Valley reservoir sites, on the Middle Fork of the Feather River. The probable available water supply from these reservoir sites is over 2,600,000 acre-feet. A reconnaissance of the entire basin of the river is almost completed. Sixteen gaging stations are being maintained in the basin, and the discharge from 82 per cent of its area is being measured. This work is being carried on in cooperation with the State of California.

The Geological Survey is making a detailed topographic map of the Sacramento Valley. The mapping of the west side of the valley will probably be completed in 1906. This map will be used in making a study of the division of the project into units.

A topographic survey was made of a reservoir site on lower Puta Creek, 10 miles above the town of Winters, Cal., and 4 or 5 miles above the point where the creek debouches upon the plain. This survey was commenced on May 9 and completed on June 5, 1905. The area of the watershed of Puta Creek above the dam site is estimated at 515 square miles, exclusive of that above the Guenoc reservoir site.

The following table gives the capacity of Puta Creek reservoir up to 150 feet depth:

Capacity of Puta reservoir.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
20	25.1	------------	--------------
30	52.1	386.0	386.0
40	106.3	802.0	1,188.0
50	181.0	1,196.5	2,384.5
60	269.0	2,000.0	4,384.5
70	365.1	3,170.5	7,555.0
80	504.1	4,346.0	11,901.0
90	664.2	5,841.5	17,742.5
100	917.4	7,908.0	25,650.5
110	1,283.5	11,004.5	36,655.0
120	1,867.5	15,755.0	52,410.0
130	2,365.1	21,163.0	73,573.0
140	2,799.3	25,822.0	99,395.0
150	3,322.7	30,610.0	130,005.0

The width of the gorge at the bottom is 80 feet, and at 150-foot elevation above the stream bed it is 380 feet. The bed rock is exposed on both banks of the stream, but not in the stream bed. The channel is filled with large bowlders. The rock is a heavy gray sandstone, and is being quarried for building purposes. A short distance above the dam site there is a large bed of gravel which will be suitable for making concrete.

The topographic surveys for the remainder of the season have been confined to the Feather River watershed, but reconnaissances for reservoir sites have been made in both the Feather and Yuba River basins. The regular topographic sheets for both of these watersheds have been completed and published by the Geological Survey and have been of great assistance in locating possible reservoir sites. The season's work in this region will be described by quadrangles.

During June and July, 1905, a survey was made on the west arm of Big Meadows, in Plumas County, Cal. The following table gives the capacity of this reservoir for greatest depth of water of 40 feet:

Capacity of western arm of Big Meadows reservoir site in Tps. 27–28 N., R. 8 E.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
4,375	966.9	------------	------------
4,385	3,927.9	24,474.0	24,474.0
4,395	7,093.0	55,104.5	79,578.5
4,405	9,893.5	84,932.5	164,511.0
4,415	12,780.0	113,367.5	277,878.5

The east arm of Big Meadows is owned and has been surveyed by the Western Power Company. The capacity given by them for greatest depth of water of 29 feet is 246,500 acre-feet. The company proposes to construct three dams. The greater part of the expense of the construction of this reservoir would be that involved in cutting off the west arm, and thus reducing the size of the reservoir. The Western Power Company proposed to furnish a copy of this survey and of the survey of the Butt Valley reservoir (capacity 100,000 acre-feet), and also of the Humbug Valley reservoir site on Yellow Creek (capacity undetermined), if the Reclamation Service would furnish the company a copy of our map of the west arm. One dam would be sufficient to make a reservoir of the east and west arms. The dam site is being prospected by the Western Power Company. Excavations have been made for bed rock on each side of the stream and the diamond drill has been used. The dam at the point where this excavation is being made will probably be considerably higher than 40 feet. The company is now combining all surveys in Big Meadows and will soon furnish a topographic map of the same.

No reconnaissance has been made on Battle, Paine, Antelope, Mill, and Deer creeks, though from the study of the Lassen Peak quadrangle there seems little likelihood that any reservoir sites of value will be discovered on these creeks. There are several meadows on these streams that are near the headwaters and have small watersheds back of them.

Indian Valley reservoir site was surveyed in August and September, 1905. The following table gives the capacity of this site:

Capacity Indian Valley reservoir.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
3,470	8.8	....	....
3,480	11.8	103.0	103.0
3,490	35.4	236.0	339.0
3,500	605.4	3,204.0	3,543.0
3,510	3,984.5	22,949.5	26,492.5
3,520	5,944.0	49,642.5	76,135.0
3,530	7,907.0	69,255.0	145,390.0
3,540	9,356.0	86,315.0	231,705.0
3,550	10,630.0	99,930.0	331,635.0
3,560	11,505.0	110,675.0	442,310.0
3,570	12,220.0	118,625.0	560,935.0
3,580	13,204.0	127,120.0	688,055.0

It is estimated that the run-off from the drainage area, which is 783 square miles, is approximately 600,000 acre-feet. The area of the surface of the reservoir will be about 20 square miles. This is the best tract of farming land in Plumas County. Mr. Johnson estimates that there are 8,000 acres of land in the tract that are worth $35 an acre, 4,000 acres worth $5 an acre, and two town sites, Taylorsville and Crescent Mills. The estimated value of the land within these sites is $50,000. In addition to this there may be some complications with the mining company that owns an old mine located within the reservoir site. This mine is now flooded, but the owners claim that they expect to pump it out and work it. The mine has been practically abandoned for a number of years. The best location for a dam site has not been fully determined, but a detailed survey has been made of the canyon for probably 2 miles of its length below the valley.

Reconnaissance has been made in Genesee Valley, which is above Indian Valley on Indian Creek, but no good dam site was discovered and no detailed survey was made on this account.

There is a large meadow, known as Mountain Meadow, in the upper part of the watershed of the North Fork of the Feather River above Big Meadows, which was not surveyed because of the small tributary watershed above it, and because of the fact that examination of the topographic sheet indicated that there was no possible dam site, though no reconnaissance was made to determine this fact.

Rock, Mud, Big Chico, Little Chico, and Butte Creek basins, in the vicinity of Chico, Cal., were examined in June and July, 1904, by L. M. Lawson. No reservoir sites of any value were discovered on any of these streams.

A survey was made of the Concow reservoir site, on Concow Creek, a tributary of the west branch of the Feather River. This was formerly an old mining reservoir of comparatively small capacity. The dam at this point failed some years ago.

A reservoir site of 45,000 acre-feet capacity is located on the west slope of the Sierra Nevada, in Plumas County, about 5 miles southwest of Edmanton, where the rainfall is 70 inches annually. This site is known as Bucks Valley. A survey of this site was made by William Watson for power purposes, probably in the interest of Mr. Hammond, of Oroville, Cal. Mr. Watson says that the principal part of the reservoir site is in private ownership and that the California Gas and Electric Company is endeavoring to get title to the dam site by covering it with a placer-mining filing. Application has been made for a patent to this land under the mining laws. No application has been filed for right of way for this reservoir site.

Meadow Valley was visited and was found to have too great a slope for a reservoir. Spanish Ranch Valley was also visited, and arrangements were made with Mr. Watson, who had surveyed this valley and American Valley, to procure copies of maps of these valleys made by him. These maps have a contour interval of 10 feet. The cost of these maps will cover only the labor of making tracings.

Arrangements have been made for copy of the topographic map of American Valley. This valley is not considered suitable for a reservoir, for the following reasons: Quincy, the largest town and the county seat of Plumas County, is located here. The final location of the Western Pacific passes through the dam site. Construction has begun on this line. Another reason is that a long auxiliary dam would be necessary in addition to the main dam across Spanish Creek canyon.

A reconnaissance was made in the upper portion of the American Valley, known as Thompson Valley, to see if this could be utilized as a reservoir, but the distance between walls—1,300 to 2,000 feet—was considered too great.

A reconnaissance was made of Long Valley, on the Middle Fork of the Feather River. It was not considered feasible to construct a reservoir here, so no detailed surveys were made.

A reconnaissance was made of Mohawk Valley, on the Middle Fork of the Feather River. The lower portion of this valley is considered to have too much grade to be of value for a reservoir site. The upper portion of the valley is now being surveyed by Mr. Johnson. The watershed tributary to this reservoir site is 652 square miles, including the watershed of Grizzly Valley.

The area of the watershed of Grizzly Valley, which is tributary to the Middle Fork of the Feather River, is 44 square miles. An excellent dam site exists here, with solid granite rock in place. Probably the most economical height to construct a dam at this point would be 100 feet, as an excellent spillway could be made for a dam at this height by excavation of rock for the dam itself. Probably a rock-fill dam would be the most economical construction. Excellent timber exists along the sides of the canyon for making a face for the dam. The hills are also covered with a considerable depth of soil, which could be sluiced in front of the dam for an earth face if it was not considered desirable to construct a wooden face. The capacity of this reservoir will probably not exceed 30,000 acre-feet with a 100-foot dam. This reservoir site might be useful in connection with an irrigation project for the northwestern portion of Sierra Valley. It is said that the people in this vicinity would be willing to undertake the formation of an irrigation district if funds could not be obtained for a Federal project, provided the construction of this reservoir was reported on favorably by the engineers of the Reclamation Service.

A reservoir site, locally known as Red Clover Valley, is located on a tributary of Indian Creek. The area of the tributary watershed is 82 square miles. It is not considered advisable to survey this reservoir site, because the dam site is very poor and, if the Indian Valley reservoir should be constructed, the discharge from the entire drainage area of Indian Creek would probably be required to fill it.

There is a reservoir site on Last Chance Creek in this neighborhood. The people of Sierra Valley have contemplated forming an irrigation district and utilizing this reservoir site. The matter was dropped, however, about six months ago because of the objection of the riparian owners on the lower part of the creek. This site is not very valuable, because of the limited area of tributary drainage and the small amount of rainfall.

A good dam site exists on the Middle Fork of the Feather River below Sierra Valley, but it was not considered advisable to survey this site or the Sierra Valley because there are railroads on both sides of the canyon of the Middle Fork of Feather River, and the reservoir itself would be too large and too shallow.

Cracrofts Neck was visited. This is in the western part of the Sierra Valley, about midway between Beckwith and Sierraville. The area of the watershed naturally tributary to this site is only about 16 square miles, and the dam site would be from 1,300 to 1,500 feet wide, so it is not considered suitable for a reservoir and is not recommended for survey. The area tributary to this reservoir site could be increased to 107 square miles by building a diversion canal from a point near Sierraville around the edge of the valley.

A copy of a topographic map has been obtained from the city engineer of San Francisco, showing the survey of the Oregon House reservoir. This survey was made in connection with one of the proposed water supplies from the Sierra Nevada for the city of San Francisco. It is not valuable as a site for an irrigation reservoir, as water would have to be brought to it by a long diversion canal. One tunnel on the line would be about 5 miles long.

Two possible reservoir sites exist in this quadrangle. One of these, Browns Valley, is occupied by an irrigation district. Another, Penn Valley, is considered impracticable for two reasons—the length of the dam necessary and the small area of the tributary watershed.

Twenty-two reservoirs have been constructed in the watershed of the South Fork of the Yuba River for mining purposes. The capacities of these reservoirs vary from 40 to 21,350 acre-feet. The most important of these were visited to determine whether it would be possible to increase their capacity by raising the dams. The total capacity of the twenty-two reservoirs is less than 87,000 acre-feet, and it is believed that the amount of storage that could be obtained by increasing the height of these dams would be insignificant. The run-off from the drainage area tributary to some of them is insufficient to fill them in average years.

Mr. Johnson is now surveying the Mohawk Valley reservoir site, and after this survey is completed the Grizzly Valley reservoir site will be surveyed if the weather permits. When these surveys are completed it is believed that maps will have been obtained of all the reservoir sites that are now available for irrigation purposes on the east side of the Sacramento Valley. A few other sites of small capacity may prove to be of sufficient value at some time in the future to justify their survey.

SAN JOAQUIN VALLEY PROJECT.

In April, 1905, investigations of the underground waters of the San Joaquin Valley were begun under the direction of W. C. Mendenhall, geologist. The plans outlined for this work contemplate a general examination of the ground-water conditions throughout the valley to determine the areas where underground waters occur in quantities sufficient to justify their development. After the areas are thus found, it is proposed to make estimates of the cost of developing the waters for irrigation purposes.

In order to determine these questions, all the more important developments that have been made by private capital are being examined. Where important developments have not been made, the smaller wells are tested, and such geologic conditions as may throw light upon the underground water supply are studied.

A base map of the San Joaquin Valley, on which the data obtained in connection with the project will be recorded, is now being prepared. Tables showing the cost and efficiency of such private enterprises as depend upon underground waters, and charts showing the artesian areas and other zones in which ground waters occur in quantity, at depths accessible for development, are being prepared, as are also reports upon all phases of the use of such waters.

OWENS VALLEY PROJECT.

The Owens Valley project has been described in the Second and Third Annual reports of the Reclamation Service, in which are given summaries of measurements showing the available water supply, together with descriptions of reservoir sites and irrigable areas. Details of stream and canal measurements in Owens Valley for the year 1903 are given in Water-Supply and Irrigation Paper No. 100 (pages 206–223), and for the year 1904 in Water-Supply and Irrigation Paper No. 134 (pages 200–261).

During the current year all work in Owens Valley has been discontinued except the sounding for bed rock at the Long Valley dam site and the continuance of stream measurements. In the summer of 1904 drilling machinery was shipped into Owens Valley for use in this exploration, but men were not available to carry on the work until May, 1905.

One dam site on Owens River below Long Valley has been explored, the work having been completed August 15 last. Eight holes have been put down at the dam site to a total depth of 293.1 feet through sand and gravel, and 352.9 feet in bed rock, a total of 646 feet. The holes were sunk to unusual depth in bed rock, owing to the fact that the rock was of volcanic origin, and it was considered possible that certain layers of the tufa might overlie strata of loose material. The greatest depth of bed rock was found to be 66 feet, and the deepest hole was put down to the depth of 128 feet. The bed rock was found to be soft but continuous. It is quite possible that bed rock at less depth could be found at other places in the canyon, but under existing conditions it was considered inadvisable to make any further expenditure of funds, largely because the prospect of constructing the dam appears quite remote. On both abutments the bed rock is exposed.

Area and capacity of proposed Long Valley reservoir.

Contour.	Area.	Capacity.
Feet.	*Acres.*	*Acre-feet.*
6,990	2	....
7,000	8	50
7,010	17	175
7,020	65	585
7,030	146	1,640
7,040	333	4,035
7,050	711	9,255
7,060	1,239	19,005
7,070	1,806	34,230
7,080	2,411	55,815
7,090	3,228	83,485
7,100	4,050	119,850
7,110	....	[a] 160,000
7,120	....	[a] 205,000
7,130	....	[a] 260,000

[a] Survey carried only to 7,100 coutour; higher capacities estimated from capacity curve.

The city of Los Angeles has obtained options for the purchase of about 60,000 acres of riparian land on Owens River, including some irrigated farms. Options have also been obtained on certain canals and on water rights. The lands contracted for are mostly in the southern portion of Owens Valley, but also include lands in the Long Valley reservoir site. The dam site is on public land, withdrawn under the first form. The question as to the purchase of lands in Owens Valley by the city of Los Angeles was decided in the affirmative at the bond election held in that city on September 7, 1905.

Because of the possibility of a conflict with the city of Los Angeles in connection with Owens River, a board of engineers was appointed by the chief engineer to consider the Owens River project. This board, consisting of W. H. Sanders, L. H. Taylor, and D. C. Henny, met in San Francisco, July 26, 1905, to define a policy with reference to the Owens Valley project. As a result of their report, and of further consideration on the part of the chief engineer and of the Secretary of the Interior, it has been decided that surveys have been carried to the point where the principal physical features are known, and it is not considered desirable to spend further funds until the legal questions relative to the situation are better understood, it having been decided that the Department could await more definite information without sacrificing the interests of the Reclamation Service.

YUMA PROJECT.[a]

Detailed information concerning the general plans and irrigable lands of this project are given in the Third Annual Report of the Reclamation Service. The estimated cost of the project, as given in these reports, is $3,000,000, which sum was set aside by the Secretary of the Interior when the project was adopted. The amount of valley lands which will be irrigated is estimated at about 90,000 acres.

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[a] See Pl. XII, Third Annual Report Reclamation Service.

During the spring and early summer of 1905 active work was partly suspended on the project on account of the floods which submerged the greater part of lands in the Yuma and Gila valleys. These floods have shown clearly the necessity of constructing works which shall give complete control of the river and the importance of constructing a settling basin for handling the silt problem, so that undue quantities of this material will not be carried into the canals. The Laguna dam, as planned, is intended to form a basin in which the velocity of the water will be checked and the greater portion of the silts allowed to settle. The water for the canals will be drawn from the surface, where it is comparatively free from silt. The water of the river will be raised about 10 feet at the dam. This will back the water up the stream about 10 miles and form a reservoir averaging about 1 mile wide. The total length of the dam is 4,780 feet. Its section is of the Indian weir type, with a maximum width at base of 257 feet, and a maximum height of 19 feet.

The valley lands will be protected from inundation by means of dikes on either side of both the Colorado and Gila rivers. These dikes will be 4,000 feet apart on the Colorado and 3,200 feet apart on the Gila. They will be 8 feet wide on top with slope of 3 to 1 on the river and 2 to 1 on the land side. Their average height will be 7½ feet. About 73 miles of dikes are required to protect all of the valley lands from inundation.

In July, 1905, after the summer floods had subsided, work leading to the preparation of final plans and the beginning of actual construction work on the project was begun.

LAGUNA DAM.[a]

On March 17, 1905, bids for the construction of the Laguna dam were opened at the office of the supervising engineer in Los Angeles. On account of delays in receiving bids, caused by extensive floods, these bids were rejected by the Secretary of the Interior and the work was readvertised. The following bids for this work were opened in Los Angeles June 5, 1905:

Bids on construction of Laguna dam.

Bidder.	Excavation.				Placing rock in dam: 305,000 cubic yards.[a]	
	Class 1: 305,000 cubic yards.		Class 2: 282,000 cubic yards.			
	Price per yard.	Amount.	Price per yard.	Amount.	Price per yard.	Amount.
J. G. White & Co., 43 Exchange place, New York	$1.30	$396,500.00	$0.30	$84,600.00	$0.35	$106,750.00
Burrell Construction Co., Oakland, Cal	1.20	366,000.00	.60	169,200.00	.09	27,450.00
P. McDonnell, Duluth, Minn.	1.30	396,500.00	.23	64,860.00	.50	152,500.00
City Street Improvement Co., 512 Mills Building, San Francisco, Cal	1.23	375,150.00	.38	107,160.00	.40½	123,525.00
Cotton Bros. & Co., Oakland, Cal	1.05	320,250.00	.63	177,660.00	.28	85,400.00
R. W. Faris, Faris-Kesl Contract Co., Boise, Idaho	1.25	381,250.00	.50	141,000.00	.40	122,000.00
Pacific Construction Co., San Francisco, Cal	1.05	320,250.00	.30	84,600.00	.70	213,500.00
N. S. Sherman Machinery Co., Oklahoma City, Okla.	1.40	427,000.00	.40	112,800.00	.60	183,000.00

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[a] See Pl. XV, Third Annual Report Reclamation Service.

Bids on construction of Laguna dam—Continued.

Bidder.	Laying pavement: 80,000 square yards.		Concrete: 27,150 cubic yards.		Furnishing and driving of sheet piling: 53,000 linear feet.		Total.
	Price per yard.	Amount.	Price per yard.	Amount.	Price per foot.	Amount.	
J. G. White & Co., 45 Exchange place, New York	$1.00	$80,000.00	$4.00	$108,600.00	$0.40	$21,200.00	$797,650.00
Burrell Construction Co., Oakland, Cal	.90	72,000.00	5.00	135,750.00	.55	29,150.00	799,550.00
P. McDonnell, Duluth, Minn.	1.00	80,000.00	4.00	108,600.00	.40	21,200.00	823,660.00
City Street Improvement Co., 512 Mills Building, San Francisco, Cal	1.00	80,000.00	4.65	126,247.50	.32$\frac{9}{10}$	17,437.00	829,519.50
Cotton Bros. & Co., Oakland, Cal	1.12	89,600.00	5.50	149,325.00	.48	25,440.00	847,675.00
R. W. Faris, Faris-Keal Contract Co., Boise, Idaho	1.00	80,000.00	4.00	108,600.00	.55	29,150.00	862,000.00
Pacific Construction Co., San Francisco, Cal	1.50	120,000.00	4.00	108,600.00	.37	19,610.00	866,560.00
N. S. Sherman Machinery Co., Oklahoma City, Okla	2.00	160,000.00	4.45	120,817.50	.50	26,500.00	1,060,117.50

The contract was awarded to J. G. White & Co., who began work July 20, 1905. The preliminary operations consist of clearing the right of way and excavating for foundations. Up to September 30, 1905, the contractors had excavated over 35,000 cubic yards of earth and cleared about 70 acres. The foundation material across the valley on the line of the dam consists of a hard, sandy silt and is considered favorable for the kind of structure planned.

The contractors are installing a plant for handling the work on a large scale. This consists of railway tracks equipped with a locomotive and cars for hauling rock to the dam, power excavators, concrete mixers, and steam rock drills. The camp will be equipped with a complete water-supply system for distilled water, electric-lighting plants for continuous work, and telephone system. Stores have been established at the dam site, and material for construction is rapidly being delivered. All supplies and material which are shipped to the dam site are carried from Yuma by boat up the river. The time allowed for the completion of the dam is two years from the date of the signing of the contract by the Secretary of the Interior.

GILA CROSSING.[a]

The capacity of the Gila crossing, plans for which are now being prepared, will be the same as that of the main canal, namely, 1,300 second-feet. This crossing will be an inverted siphon 3,200 feet long, consisting of four steel concrete pipes, each 10 feet 6 inches inside diameter. The pipes will be sunk to a depth of about 3 feet clear below the bed of the river.

GILA VALLEY.

The unusual spring floods of the Gila River have materially changed the topography of the valley and have altered the course of the river's channel at the site selected for the Gila crossing. This has required the making of a new topographic survey of about 30 square miles in the valley. This survey was made during August and September. A relocation of about 10 miles of the main canal across the Gila Valley is now being made. The capacity of this main canal for present construction has been fixed at 1,300 second-feet, the capacity required for the valley lands.

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[a] See Pl. XVI, Third Annual Report Reclamation Service.

DIKES.

Bids for the construction of about 10 miles of dikes below Yuma were opened at Los Angeles on August 17, 1905. This contract involves the excavation and placing of 445,000 cubic yards of earth and the clearing of 125 acres of right of way. Bids received were as follows:

Bids received for the construction of dike in Yuma Valley.

Bidder.	Excavation: 445,000 cubic yards.		Overhaul: Price per cubic yard, 100 feet.	Clearing and grubbing: 125 acres.		Total.	Remarks.
	Price per cubic yard.	Amount.		Price per acre.	Amount.		
Miller & Peasley, 233 Wilcox Building, Los Angeles, Cal.	$0.13½	$60,075.00	$0.01	$50.00	$6,250.00	$66,325.00	Entire schedule.
Do	.14	62,300.00	.01	100.00	12,500.00	....	One or more items.
Grant Bros. Construction Co., 604 Trust Building, Los Angeles, Cal.	.17	75,650.00	.02½	85.00	10,625.00	86,275.00	Entire schedule.
J. G. White & Co., 43 Exchange place, New York City, N. Y.	.18	80,100.00	.01	90.00	11,250.00	91,350.00	Do.
Shattuck Desmond Warehouse Co., Ninth and Alameda streets, Los Angeles, Cal.	.21¾	96,787.50	.02	15.00	1,875.00	98,662.50	Do.
Do	.30	133,500.00	.04	25.00	3,125.00	....	One or more items.

GATES.

The plans for the sluice gates for the Laguna dam are completed and have been approved by the board of consulting engineers. They are to be four in number, three of them on the Arizona side, of Stoney type, each 33 feet 4 inches wide by 18 feet high, operated by electric motors. The gate on the California side will not be installed for the present. The plans for the regulator gates are finished and ready to be submitted to the board. The latter plans provide for steel gates, each 33 feet 6 inches wide, of the shutter type, to be operated by hand. The capacity of the regulator gates is such that the main canal can be filled by drawing but from 1 to 1.65 feet deep from the surface of the water in the settling basin. Alternate plans for flashboard regulation have been drawn.

PURCHASE OF CEMENT.

Owing to immediate needs for cement on the construction of the Laguna dam, authority was obtained from the Secretary of the Interior for the purchase in open market for immediate delivery of 2,000 barrels of cement. The price paid for this cement delivered on board cars at the factory at Tolenas, Cal., is $1.50 per barrel.

On September 30 bids were opened for the purchase of between 30,000 and 40,000 barrels of cement, to be delivered as the needs of the work may require. The bids received on this proposal were as follows:

Bids for cement for Laguna dam.

Name of bidder.	Delivered on board cars at—	Price per barrel.
Pacific Portland Cement Co., San Francisco, Cal	Tolenas, Cal	$1.55
Western States Portland Cement Co., Independence, Kans	Yuma	4.10
	Independence, Kans	1.25
Western Fuel Co., San Francisco, Cal	Napa Junction, Cal	1.60
California Portland Cement Co., Los Angeles, Cal	Colton, Cal	2.45

The lowest bid, based on cost of cement f. o. b. Yuma, is that of the Pacific Portland Cement Company, the cost of whose cement to the Government at Yuma will be $2.82 per barrel.

PRIVATE CANALS.

The floods of the past winter and spring have deposited large quantities of silt over the valley lands below Yuma and have filled, to a great extent, both the Farmers' and the Ludy gravity canals. In addition the level of the Colorado River seems to have fallen about 2 feet, and the water surface in the river is now about 5 feet below the bottom of both these canals. The gravity canals have been dry all summer, and large areas of the farming lands in the valley are now without water. The Farmers' pump canal, which is on a higher level than the other canals and of sufficient elevation to deliver water to the lands, is now being operated.

Negotiations for the sale of the Farmers' canals to the United States for use in connection with the Yuma project are now pending between the owners of the canals and the officers of the Reclamation Service. Satisfactory terms for the sale of the Ludy canal have not yet been reached on account of the price asked.

RIGHTS OF WAY.

Rights of way are gradually being obtained for all lands in the Laguna reservoir site. All private properties in this area in Arizona are claims on unsurveyed lands. These are largely desert-land entries, though some are homestead and a few are mining claims.

An agreement has been reached and has been approved for the purchase of the Sass mining claims for $6,000. The left abutment of the Laguna dam and the spillway are on these claims.

Rights of way for the 12 miles of dikes below Yuma have nearly all been obtained.

WATER USERS' ASSOCIATION.

The Water Users' Association has secured the assignment, under the terms of the reclamation act, of 98 per cent of all lands held in private ownership under the project. These assignments provide for the disposal of all excess holdings above the maximum area to which water will be furnished for any one person.

The contract between the Water Users' Association and the Secretary of the Interior, by which the association agrees to collect all moneys due from the water users and pay them to the Secretary of the Interior under the terms of the reclamation act, has been signed by the officers of the association and submitted to the Secretary for approval.

EXPENDITURES.

The total expenditure on the Yuma project to September 30, 1905, for preliminary examinations along the Colorado River from The Needles to the Mexican line, including the investigation of the Imperial Valley, final surveys of the canals, etc., designs of the Laguna dam and Yuma dike, construction of office buildings, quarters, and storehouses, purchase of lands, and administration amounted to $254,929.98.

INVESTIGATIONS IN THE IMPERIAL VALLEY.

GENERAL STATEMENT.

The Imperial Valley is situated in the eastern portion of San Diego County, Cal., between the Cuyamaca or Laguna Mountains on the west and a high sandy mesa on the east. (See Pl. IX.) On the south the valley is bordered by the lands of Lower California. At the Mexican boundary the valley is practically at sea level. From this point the slope is fairly uniform down to an elevation of 287 feet below sea level, near Salton. The area below sea level comprises about 1,000,000 acres, and is commonly known as the "Salton Sink."

In 1901 work was begun on the project for supplying water from the Colorado River to be used for irrigation and domestic use in the lands of the Imperial Valley. Water for the valley was diverted from Colorado River near the international boundary and conveyed through Mexican territory a distance of approximately 60 miles and thence reconveyed into the United States, where it was used. The organization of the enterprise consisted of the Sociedad de Irrigación y Terrenos de la Baja California, known as the "Mexican Company," the California Development Company, known as the "parent company," and the various mutual water companies. The Mexican company was the owner of the lands, canals, and other properties situated in Mexico. The stock of the Mexican company was owned and controlled by the officers of the California Development Company, and the latter company made contracts with the mutual water companies for the delivery of water to them. The holders of the stock in the mutual companies, which represented an interest in the contract with the California Development Company, were entitled to purchase water.

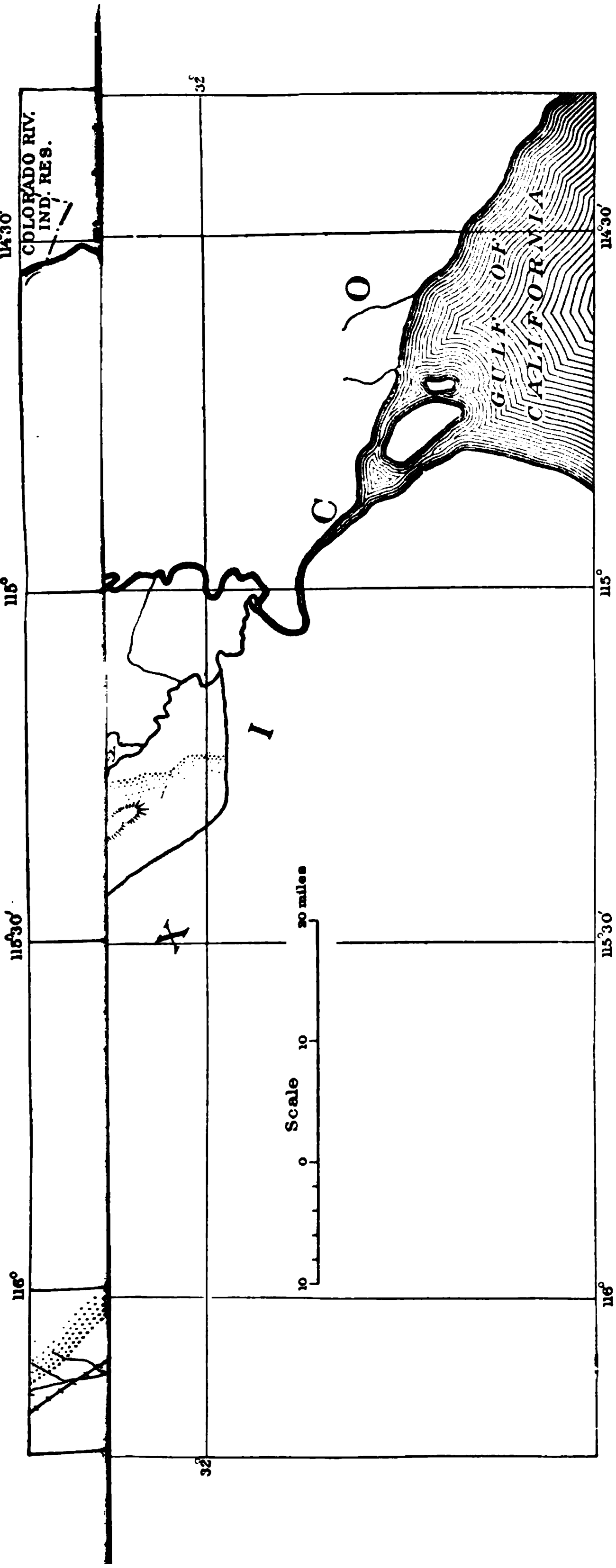
A main canal was excavated from the Colorado River, a few hundred feet north of the international boundary, a distance of about 7 miles, to the old channel of the Alamo or Salton River. For the remainder of the distance nearly to the Imperial Valley this old channel was used as a main canal.

Water was first brought into the Imperial Valley in July, 1901. During the summer months of 1901 it is reported that 1,500 acres were put under irrigation. This was increased to 12,000 during the summer of 1902, and still further increased in 1903.

During the summer of 1904 the water users of the Imperial Valley requested the officers of the Reclamation Service to consider the purchase of the works of the California Development Company, and to complete the system under the reclamation act. This request was based upon a tentative agreement made

U. S. GEOLOGICAL SURVEY

FOURTH ANNUAL REPORT RECLAMATION SERVICE PL. IX



MAP OF IMPERIAL VALLEY AND LOWER COLORADO RIVER, CALIFORNIA-ARIZONA.

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between the water users and the California Development Company, providing for the sale of the property of the California Development Company for $3,000,000, a portion of the water users agreeing informally that the purchase price and the cost of completing the system should be borne by the lands of the valley.

WORK ON THE PROJECT.

In August, 1904, D. W. Murphy, engineer, was assigned to the work of making an examination of the Imperial canal system, and of preparing estimates of the cost of construction, the present value, and the cost of putting in permanent structures and completing the system.

An investigation of the amount of good irrigable lands in the valley was also made at this time. Gaging stations were established on the canals of the valley and a hydrographer was placed in charge to determine the actual amount of land irrigated, the quantity of water used, the amount being wasted into the Salton Sea, and the duty of water in the valley. The purpose of these investigations, in addition to those set forth in the resolution of Congress, was to determine whether the general conditions in the valley would justify the consideration of a project by the Reclamation Service.

IRRIGABLE LANDS.

The amount of irrigable lands in the valley was based upon the soil survey of the Imperial area made by the Department of Agriculture. The conclusions arrived at from the report of this survey and from field examinations is that there are approximately 275,000 acres of irrigable land in the valley suitable for agricultural purposes.

CONSIDERATION OF THE PROJECT.

In October, 1904, the chief engineer of the Reclamation Service, accompanied by Senator Bard, Messrs. Wisner, Sanders, Lippincott, Bien, Means, and Murphy, of the Reclamation Service, and Messrs. Holmes and Dorsey, of the Agricultural Department, made an inspection of the valley. The question of the United States acquiring the canal system by purchase, to be completed under the reclamation act, was later considered by the officers of the Reclamation Service. This purchase was strongly urged by many of the water users and settlers of the valley. The offer to sell the property was not considered, because the Attorney-General held that the international features of the project were prohibitory under the law, and the price asked was also considered excessive.

LANDS IRRIGATED IN THE IMPERIAL VALLEY.

In April, 1904, an examination was made to determine the amount of lands irrigated in the valley. The gross area under irrigation at that time was 66,741 acres. A second examination was made in September of the same year by W. V. Hardy, of the Reclamation Service, and showed the total area irrigated at that time to be 30,017 acres. A second examination by Mr. Hardy in March and April, 1905, gave a total irrigated area of 79,591 acres.

DUTY OF WATER INVESTIGATIONS.

Investigations for the determination of the duty of water for different crops were begun during the latter part of 1904. These investigations are being made on both the clays and the softer soils of the valley, two stations being maintained. The water measurements are made by means of rating flumes, upon which weekly gagings are made, and a continuous record of gage readings taken. The results of these investigations will not be complete until a full year's record is obtained.

CANAL MEASUREMENTS.

Gaging stations have been maintained on the Imperial Canal at the Colorado River heading and on all canals returning to the United States at the international boundary in the Imperial Valley. The amount of water which passed through the valley and was wasted into the Salton Sea by the channels of New and Alamo rivers has been separately measured. The results of measurements on the canals entering the Imperial Valley are shown in the following table:

Gaging of the canals entering the Imperial Valley at crossing of international boundary.

[Volumes in second-feet.]

Date.	Holt canal.	Hemlock canal.	Alamo channel.	Alamitos canal.	Boundary canal.	Main canal.	Total.[a]
1904.							
July 14	62.0	....	144.0	28.6	....	615.0	....
July 21	....	....	....	....	....	642.0	....
July 22	53.6	4.4	115.0	24.8	10.0	625.0	832.8
July 26	48.4	6.4	138.0	18.4	10.0	598.0	819.2
July 29	44.0	6.0	177.0	26.3	9.1	519.0	781.4
August 2	43.0	3.6	39.0	8.2	12.7	652.0	758.5
August 5	41.8	7.3	36.5	13.3	13.0	677.0	788.9
August 10	50.0	4.4	163.0	3.0	10.5	556.0	786.9
August 17	59.0	5.7	219.0	17.7	8.3	644.0	953.7
August 23	56.0	5.0	200.0	17.4	11.9	669.0	959.3
August 26	56.0	4.9	197.0	15.6	15.6	696.0	985.1
September 3	60.0	4.3	239.0	16.3	13.2	717.0	1,049.8
September 10	61.0	4.6	256.0	21.0	12.9	682.0	1,037.5
September 18	37.0	11.5	136.0	31.0	7.5	662.0	885.0
September 24	36.0	3.9	124.0	8.3	11.0	573.0	756.0
September 27	33.0	4.5	185.0	13.7	9.9	560.0	769.0
October 1	49.0	14.5	240.0	8.4	10.8	249.0	572.0
October 5	41.0	5.4	123.0	18.7	10.0	474.0	672.0
October 8	56.0	8.2	205.0	36.0	9.4	548.0	863.0
October 15	48.0	8.8	182.0	35.0	5.9	642.0	921.0
October 22	47.0	10.6	228.0	26.0	7.0	639.0	957.0
October 29	30.0	3.1	157.0	25.0	7.0	656.0	876.1
November 4	36.3	6.4	146.0	23.0	6.2	598.0	816.0
November 11	54.0	8.0	152.0	30.0	6.6	601.0	851.6
November 18	50.0	8.2	97.0	35.0	6.3	620.0	816.5
November 25	40.0	8.0	86.0	26.0	6.2	602.0	768.2
December 2	32.0	9.5	80.0	22.0	7.0	586.0	736.5
December 8	37.0	6.3	107.0	25.0	4.8	573.0	753.1
December 15	27.0	3.3	111.0	26.0	5.5	561.0	733.8
December 22	32.0	1.8	80.0	29.0	4.0	563.0	709.8
1905.							
January 3	....	....	....	30.0	6.4	439.0	475.4
January 4	19.5	2.0	102.0	....	....	....	123.5
January 11	....	....	....	39.0	8.6	524.0	571.6

[a] This column does not represent total discharge into Salton Sea.

Gaging of the canals entering the Imperial Valley at crossing of international boundary—Continued.

Date.	Holt canal.	Hemlock canal.	Alamo channel.	Alamitos canal.	Boundary canal.	Main canal.	Total.[a]
1905.							
January 12	30.0	2.2	121.0				153.2
January 18				15.1	8.9	567.0	591.0
January 19	28.0	9.5	136.0				173.5
January 25					7.8		7.8
January 26	19.5	1.9	54.0	12.9		510.0	598.3
February 2	18.1	7.4	84.0	13.6	9.1	507.0	639.2
February 9	13.5	16.4	123.0	1.0	8.3		162.2
February 15						485.0	485.0
February 17	40.0	12.5	221.0	16.8	5.1	472.0	767.4
February 23					8.8	447.0	455.8
February 24	11.1	17.2	39.0	15.7			83.0
March 1	(b)	(b)		9.1	10.0	595.0	614.1
March 8				.0	.0	.0	.0
March 13	51.0	8.7	616.0				675.7
March 15				.0	.0	.0	.0
March 20	64.0	13.2	(c)				77.2
March 22				.0	7.8	410.0	417.8
March 27	118.0	23.0	(c)				141.0
March 29				24.0	6.2	651.0	681.2
April 3	131.0	20.0	487.0				638.0
April 5				44.0	8.5	675.0	727.5
April 10	21.0	12.7	711.0				744.7
April 11				50.0	10.4	729.0	789.4
April 17	246.0	36.0	713.0	57.0	11.7	735.0	1,798.7
April 24	256.0	1.6	(c)	40.0	13.0	725.0	1,035.6
May 1	202.0	6.4	683.0	26.0	6.1	648.0	1,571.5
May 8	143.0	20.0	874.0	28.0	7.5	623.0	1,695.5
May 15	163.0	18.6	(d)	39.0	6.1	586.0	812.7
May 22	169.0	14.5		35.0	5.1	562.0	785.6
May 29	128.0	12.1		36.0	8.0	595.0	779.1
June 5	150.0	16.9		36.0	8.4	566.0	777.3
June 12	177.0	2.1		37.0	.22	575.0	791.3
June 18	57.0	13.2		30.0	11.0	540.0	651.2
June 26	50.0	21.0		36.0	7.5	571.0	685.5
July 3	6.9	7.2			6.4	572.0	592.5
July 5				34.0			34.0
July 10	6.1	17.9		33.0	4.8	567.0	628.8
July 17	5.8	15.9		34.0	4.2	582.0	641.9
July 24	4.8	.8		33.0	6.6	583.0	628.2
July 31	4.2	7.9		33.0	5.3	580.0	630.4
August 7	30.0	12.7		22.0	6.2	556.0	626.9
August 14	[e]212.0	17.4		22.0	5.7	562.0	819.1
August 21	[e]90.1	9.8		24.0	5.7	540.0	669.6
August 28	133.0	7.3		31.0	4.8	536.0	712.1
September 4	131.0	4.4		39.0	3.8	558.0	736.2
September 11					.0	[f].0	.0

[a] This column does not represent total discharge into Salton Sea.
[b] Station inaccessible account of high water.
[c] Water overflowing banks.
[d] May 15 to June 12, river overflowing banks. No gagings made.
[e] Combined discharge of canal at regular station and at point 1 mile below.
[f] Canal broken.

The water wasted into the Salton Sea is shown by the following table:

Gagings of canals discharging water into the Salton Sea.

[Volumes in second-feet.]

Date.	New River.[a]	Alamo channel at Rockwood.	Other canals.[b]	Total.[c]
1904.				
October 10	208			208
October 11		43		43
October 18	380	45		425
October 19			77	77
October 31	381			381
November 1		59	58	117
November 9	318	49	0	367
November 15		117	1	118
November 16	270			270
November 22		81	3	84
November 24	311			311
November 30	231	73	0	304
December 6	257	46	0	303
December 13	301	52	0	353
December 24	254	39	0	293
1905.				
January 7	232	49		281
January 14	569	205		774
January 21	468	77		545
January 28	663	112		775
February 4	592	151		743
February 11	1,029	61		1,090
February 20		530		530
February 21	1,507			1,507
February 25	1,625	94		1,719
March 3	2,403	387		2,790
March 11	2,110	1,088		3,198
March 17	2,108	1,379		3,487
March 25	1,311	1,806		3,117
March 30	1,960	1,443		3,403
April 8	1,470	635		2,105
April 13	1,151	692		1,843
April 19	1,115	772		1,887
April 26	2,251	1,632		3,883
May 3	2,091	1,044		3,135
May 10	2,136	1,770		3,906
May 17	2,550	990		3,540
May 24	3,023	1,562		4,585
May 31	3,071	1,692		4,763
June 7	4,054	2,110		6,164
June 14	4,244	3,644		7,888
June 21	4,984	5,348		10,332
June 28		3,253		3,253
July 5	11,943			11,943
July 6		4,234		4,234
July 12	13,645			13,645
July 13		3,932		3,932

[a] Observations to June 28, 1905 made at Brawley; from July 5 to September 13 at Calexico.
[b] Figures for 1904 relate to Canal No. 5, at Bernice.
[c] This column does not represent total discharge into Salton Sea.

Gagings of canals discharging water into the Salton Sea—Continued.

Date.	New River.	Alamo channel at Rookwood.	Other canals.	Total.[a]
1905.				
July 18	13,224		325	13,549
July 19		3,501		3,501
July 25	10,037		318	10,355
July 26		3,104		3,104
August 1	8,221		321	8,542
August 2		3,551		3,551
August 8	6,581			6,581
August 9		2,815		2,815
August 15	6,997			6,997
August 16		2,874	315	3,189
August 22	5,529			5,529
August 23		2,439		2,439
August 29	4,808			4,808
August 30		2,509		2,509
September 5	3,830			3,830
September 6		2,115	250	2,365
September 12	1,892			1,892
September 13		[b] 3,500		3,500

[a] This column does not represent total discharge into Salton Sea.
[b] Estimated. Station wrecked.

PRESENT CONDITION COLORADO RIVER HEADING.

The original diversion of the Imperial canal at the Colorado River was made in the United States a short distance above the international boundary. Later a second diversion was made immediately below the boundary line, and in October, 1904, a third diversion, heading 4 miles farther down the river, was made. None of these canals have head-gates.

The heavy flood discharge of the Colorado River during the winter and spring of 1905 caused an erosion of the latter heading, No. 3. On June 1 the amount of water being diverted through this heading was 4,498 second-feet, and the total diversion into the Imperial canal system was 6,737 second-feet. At this time the total discharge of the Colorado River, as measured at Yuma, was approximately 60,000 second-feet. On June 23 the discharge of heading No. 3 was 6,883 second-feet, the total discharge into the canal system was 10,142 second-feet, and the river discharge was over 90,000 second-feet.

As the flood of the Colorado receded the proportion of the river diverted to the canal increased rapidly, and measurements made on September 22 and 23 showed that with a total river discharge of 6,063 second-feet at Yuma, only 175 second-feet were discharging down the main channel of the river below the canal heading. This shows that over 97 per cent of the entire Colorado River was then flowing into the canal.

Efforts have been made to check this flow and divert the water back to the river channel by means of pile-and-brush dams; these have been unsuccessful. An attempt is now being made by the California Development Company to construct a head-gate in the canal below the diversion point, so that the waters may be turned back into the river channel. The grade of the canal from the heading to the Salton Sink is over three times as steep as that of the river below the heading and the flow of this large quantity of water through the canal has eroded a channel about 600 feet wide below the diversion point and has cut out the bed of the canal so that it is several feet below the bed of the river channel farther downstream. The discharge of this water into the Salton Sea has caused it to rise so high that it has submerged about 20 miles of the main line of the Southern Pacific Company's tracks. Should the river not be diverted to its old channel and the entire flow of the Colorado River be allowed to discharge into the Salton Sea, that body of water will gradually rise until the Imperial Valley is finally submerged.

SHASTA VALLEY INVESTIGATIONS.

LOCATION.

Reconnaissance surveys to determine the amount of irrigable land and the collection of data for preliminary study of the feasibility of an irrigation project in the Shasta Valley were made during the summer of 1905 by Mr. W. D. Williams, assistant engineer.

This valley extends northward from the base of Mount Shasta, in Siskiyou County, Cal. The main valley lies at an elevation of between 2,000 and 3,000 feet, and is traversed by Shasta and Little Shasta rivers.

Shasta River rises in the high mountains west of Mount Shasta, flows northwestward, and empties into Klamath River below Klamathon, on the lower or western side of the valley. Little Shasta River rises north of Mount Shasta and flows westward, emptying into Shasta River above the point where that stream unites with Klamath River. These two streams divide the valley into two sections, known as the Shasta and Little Shasta valleys.

The main line of the Southern Pacific Company traverses the center of the valley north and south, and affords excellent railroad facilities. The principal towns are Montague and Yreka. Yreka, the county seat of Siskiyou County, is on the western side of the valley and is connected with the Southern Pacific Railway at Montague by the Yreka Railroad, a branch line 6 miles long.

CLIMATE, SOIL, AND CROPS.

The climate is semiarid. The precipitation records kept at Yreka for the past twenty-nine years show a mean annual rainfall of 17.6 inches, which is believed to be slightly in excess of the average rainfall throughout the valley. The period of rainfall is confined practically to the nine months from October to June, inclusive, the average annual rainfall for the remaining three months being only one-half inch.

The temperature varies from 90° to 110° F. in summer. The winters, which are mild, are followed by occasional late frosts, which in the past have seriously affected the fruit industry. The soil is diversified. That of the western portion of the main valley and the greater part of Little Shasta Valley is a heavy adobe, deposited to a considerable depth over an irregular bed of lava; that of the eastern portion of the main valley is a sandy loam, while that of the southern portion of the Little Shasta Valley, locally known as "The Cedars," is principally an alluvial deposit derived from the adjacent hills, the underlying strata being a mixture of pumice and lava rock.

The principle crops grown are wheat and barley, the average yield for these ranging from 10 to 30 bushels per acre. Alfalfa lands, when irrigated, produce two good crops and pasture for the remainder of the season. At present there are about 5,000 acres under irrigation in the Little Shasta Valley.

IRRIGABLE LANDS.

From the preliminary surveys it is estimated that there are 70,600 acres of land in the valley susceptible of irrigation. Of this amount 65,600 acres may be irrigated from Klamath River, and the remaining 5,000 acres from Little Shasta River and adjacent springs.

Water for the valley can be diverted from Klamath River in Oregon 7 miles below Shovel Creek. The length of main canal required to the first diversion point is about 34 miles, and its estimated capacity is 656 second-feet. The length of the east branch canal, for supplying water to the Little Shasta Valley, is about 24 miles, and its estimated capacity is 336 second-feet. These capacities are based upon a water duty of 100 acres to the second-foot, with constant flow during the irrigation period.

PRESENT CONDITIONS.

The people of Shasta Valley desire Government irrigation, and are willing to comply with the terms of the reclamation act. An examination of the records show that practically all the irrigable lands in the valley are held in private ownership.

The preliminary estimate of the cost of constructing the irrigation system is not yet fully completed, but the work will be very heavy and expensive, and it is feared that for the present the cost will be prohibitive.

OPERATIONS IN COLORADO.

By J. H. QUINTON.

UNCOMPAHGRE VALLEY PROJECT.

Operations on the Uncompahgre Valley project (Pl. X) during the years 1902, 1903, and 1904 are described in the annual reports of the Reclamation Service for those years.

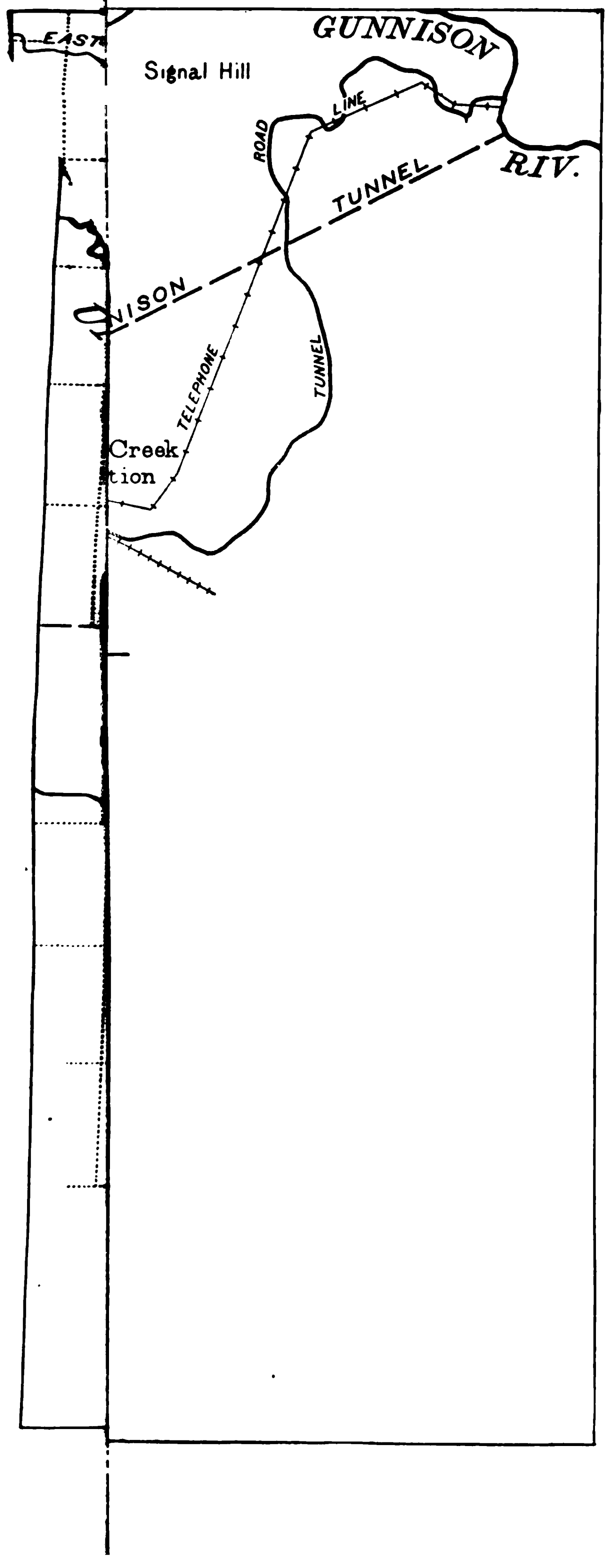
From November 1, 1904, to October 31, 1905, the work done has been mainly that of construction, with surveys on certain special features of the work.

SOUTH CANAL.

Early in November, 1904, contracts were closed with Orman & Crook, of Pueblo, Colo., for the construction of sections 3, 4, and 5 of the south canal; with the Knowlton & Bollen Construction Company, of Fort Collins, Colo., for sections 1, 2, 7, 8, and 9, and with Kellogg & Worley, of Gunnison, Colo., for section 6. Orman & Crook completed their work in April, 1905. The Knowlton & Bollen Construction Company completed their work in June, 1905. Kellogg & Worley completed their work in September, 1905. The total contract price of the nine sections was $84,493.50.

On August 28, 1905, bids were received on sections 10–21, inclusive. The bids received are given below. The contract for the entire twelve sections was awarded to Orman & Crook, of Pueblo, Colo., at a total estimated price of $513,365. The cement for the structures is to be furnished by the United States and will cost about $60,000. About 4,300 feet of this canal remain to be completed, at a probable cost of $15,000, making the total cost for the entire canal, including engineering expenses, about $690,000. Views of the south canal are shown on Pl. XI, and sections of the canal and structures are shown on Pls. XII, XIII, and XIV.

U. S. RTH ANNUAL REPORT RECLAMATION SERVICE PL. X



SERVICE PL. XI

Valley project.

Bids on South canal, Uncompahgre Valley project.

Division and work.	Quantity.	Orman & Crook, Pueblo, Colo.		Samuel Treais, Montrose, Colo.		Smith Bros., Montrose, Colo.		Knowlton & Bollen Construction Co., Fort Collins, Colo.		William S. Henderson, Montrose, Colo.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Division 10:											
Excavation—											
Class 1 ... cubic yards	11,000	$0.17	$1,870.00							$0.30	$3,300.00
Class 2 ... do	16,000	.30	4,800.00							.40	6,400.00
Class 3 ... do	10,000	.37	3,700.00							.60	6,000.00
Class 4 ... do	5,000	.75	3,750.00							1.10	5,500.00
Overhaul ... do	2,000	.02	40.00							.04	80.00
Refilling ... do	200	.50	100.00							1.00	200.00
Paving ... square yards	1,100	2.00	2,200.00							3.00	3,300.00
Dry rubble masonry ... cubic yards	50	5.00	250.00							3.00	150.00
Concrete—											
Class 1 ... do	1,800	9.00	16,200.00							16.00	28,800.00
Class 2 ... do	1,800	7.50	13,500.00							10.00	18,000.00
Laying pipe, 36-inch ... linear feet	250	2.00	500.00							1.00	250.00
Furnishing and placing steel for concrete reenforcement—											
Railroad rails, 40 pounds to the yard ... pounds	38,000	.05½	2,090.00							.08	3,040.00
Railroad rails, 16 pounds to the yard ... do	41,000	.06	2,460.00							.07	2,870.00
Total			51,460.00								77,890.00
Division 11:											
Excavation—											
Class 1 ... cubic yards	6,000	.15	900.00								
Class 2 ... do	4,000	.30	1,200.00								
Class 3 ... do	15,000	.37	5,550.00								
Class 4 ... do	6,000	.75	4,500.00								
Overhaul ... do	5,000	.02	100.00								
Refilling ... do	100	.50	50.00								

Bids on South canal, Uncompahgre Valley project—Continued.

Division and work.	Quantity.	Orman & Crook, Pueblo, Colo.		Samuel Treais, Montrose, Colo.		Smith Bros., Montrose, Colo.		Knowlton & Bollen Construction Co., Fort Collins, Colo.		William S. Henderson, Montrose, Colo.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Division 11—Continued.											
Paving .... square yards..	800	$2.00	$1,600.00								
Concrete—											
Class 1 .... cubic yards..	900	9.00	8,100.00								
Class 2 .... do....	700	7.50	5,250.00								
Laying pipe, 24-inch .... linear feet..	200	1.75	350.00								
Furnishing and placing steel for concrete reenforcement—											
Railroad rails, 40 pounds to the yard .... pounds..	15,000	.05½	825.00								
Railroad rails, 16 pounds to the yard .... do....	16,000	.06	960.00								
Total			29,885.00								
Division 12:											
Excavation—											
Class 1 .... cubic yards..	5,000	.15	750.00								
Class 2 .... do....	4,000	.30	1,200.00								
Class 3 .... do....	11,000	.37	4,070.00								
Class 4 .... do....	6,000	.75	4,500.00								
Overhaul .... do....	1,000	.02	20.00								
Refilling .... do....	600	.50	300.00								
Paving .... square yards..	1,000	2.00	2,000.00								
Dry rubble masonry .... cubic yards..	100	5.00	500.00								
Concrete—											
Class 1 .... do....	700	9.00	6,300.00								
Class 2 .... do....	150	7.50	1,125.00								
Laying pipe, 24-inch .... linear feet..	100	1.75	175.00								
Total			20,940.00								

Division 13:											
Excavation—											
Class 1 ... cubic yards	7,000	.17	1,190.00	$0.30	$2,100.00						
Class 2 ... do	7,000	.33	2,310.00	.40	2,800.00						
Class 3 ... do	14,000	.40	5,600.00	.60	8,400.00						
Class 4 ... do	8,000	.75	6,000.00	1.10	8,800.00						
Overhaul ... do	2,000	.02	40.00	.04	80.00						
Refilling ... do											
Paving ... square yards	50	2.00	100.00	3.00	150.00						
Dry rubble masonry ... cubic yards	200	5.00	1,000.00	5.00	1,000.00						
Concrete—											
Class 1 ... do	1,000	9.00	9,000.00	19.00	19,000.00						
Class 2 ... do	50	7.50	375.00	17.00	850.00						
Laying pipe, 36-inch ... linear feet											
Tunnel—											
Class 1 ... do	300	33.00	9,900.00	20.50	6,150.00						
Class 2 ... do	200	56.75	11,350.00	22.50	4,500.00						
Total			46,865.00		53,830.00						
Division 14:											
Excavation—											
Class 1 ... cubic yards	3,000	.17	510.00	.30	900.00						
Class 2 ... do	3,000	.33	990.00	.40	1,200.00						
Class 3 ... do	4,000	.40	1,600.00	.60	2,400.00						
Class 4 ... do	3,000	.75	2,250.00	1.10	3,300.00						
Overhaul ... do	1,000	.02	20.00	.04	40.00						
Refilling ... do	50	.50	25.00	1.00	50.00						
Paving ... square yards	100	2.00	200.00	3.00	300.00						
Dry rubble masonry ... cubic yards	1,000	5.00	5,000.00	5.00	5,000.00						
Concrete—											
Class 1 ... do	800	9.00	7,200.00	19.00	15,200.00						
Class 2 ... do	20	7.50	150.00	17.00	340.00						
Laying pipe, 36-inch ... linear feet	100	2.00	200.00	1.00	100.00						

Bids on South canal, Uncompahgre Valley project—Continued.

Division and work.	Quantity.	Orman & Crook, Pueblo, Colo.		Samuel Treais, Montrose, Colo.		Smith Bros., Montrose, Colo.		Knowlton & Bollen Construction Co., Fort Collins, Colo.		William S. Henderson, Montrose, Colo.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Division 14—Continued.											
Tunnel—											
Class 1 .... linear feet..	200	$33.00	$6,600.00	$20.50	$4,100.00	....	....	....	....	....	....
Class 2 .... do....	200	56.25	11,250.00	22.50	4,500.00	....	....	....	....	....	....
Total	....	....	35,995.00	....	37,430.00	....	....	....	....	....	....
Division 15:											
Excavation—											
Class 1 .... cubic yards..	5,000	.18	900.00	.65	3,250.00	....	....	....	....	....	....
Class 2 .... do....	6,000	.33	1,980.00	.80	4,800.00	....	....	....	....	....	....
Class 3 .... do....	10,000	.40	4,000.00	1.00	10,000.00	....	....	....	....	....	....
Class 4 .... do....	5,000	.80	4,000.00	1.25	6,250.00	....	....	....	....	....	....
Overhaul .... do....	2,000	.02	40.00	.04	80.00	....	....	....	....	....	....
Refilling .... do....	100	.50	50.00	1.00	100.00	....	....	....	....	....	....
Paving .... square yards..	100	2.00	200.00	3.00	300.00	....	....	....	....	....	....
Dry rubble masonry .... cubic yards..	100	5.00	500.00	5.00	500.00	....	....	....	....	....	....
Concrete—											
Class 1 .... do....	700	9.00	6,300.00	19.00	13,300.00	....	....	....	....	....	....
Class 2 .... do....	50	7.50	375.00	17.00	850.00	....	....	....	....	....	....
Tunnel—											
Class 1 .... linear feet..	500	33.00	16,500.00	20.50	10,250.00	....	....	....	....	....	....
Class 2 .... do....	500	57.25	28,625.00	22.50	11,250.00	....	....	....	....	....	....
Total	....	....	63,470.00	....	60,930.00	....	....	....	....	....	....

Division 16:											
Excavation—											
Class 1 .... cubic yards..	25,000	.18	4,500.00								
Class 2 .... do....	25,000	.33	8,250.00								
Class 3 .... do....	32,000	.40	12,800.00								
Class 4 .... do....	10,000	.80	8,000.00								
Overhaul .... do....	5,000	.02	100.00								
Refilling .... do....	500	.50	250.00								
Paving .... square yards..	1,200	2.00	2,400.00								
Dry rubble masonry .... cubic yards..	800	5.00	4,000.00								
Concrete—											
Class 1 .... do....	3,900	9.00	35,100.00								
Class 2 .... do....	2,500	7.50	18,750.00								
Laying pipe, 36-inch .... linear feet..	100	2.00	200.00								
Laying pipe, 24-inch .... do....	100	1.75	175.00								
Furnishing and placing steel for concrete reenforcement—											
Railroad rails, 40 pounds per yard .... pounds..	53,000	.05½	2,915.00								
Railroad rails, 16 pounds per yard .... do....	57,000	.06	3,420.00								
Total			100,860.00								
Division 17:											
Excavation—											
Class 1 .... cubic yards..	6,000	.15	900.00								
Class 2 .... do....	6,000	.30	1,800.00								
Class 3 .... do....	20,000	.37	7,400.00								
Class 4 .... do....	8,000	.75	6,000.00								
Overhaul .... do....	30,000	.02	600.00								
Refilling .... do....	1,700	.50	850.00								
Paving .... square yards..	2,300	2.25	5,175.00								
Dry rubble masonry .... cubic yards..	300	5.50	1,650.00								
Concrete—											
Class 1 .... do....	1,100	9.00	9,900.00								
Class 2 .... do....	600	7.50	4,500.00								
Laying pipe, 24-inch .... linear feet..	200	1.75	350.00								
Total			39,125.00								

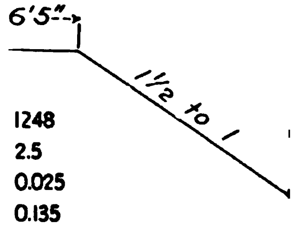
Bids on South canal, Uncompahgre Valley project—Continued.

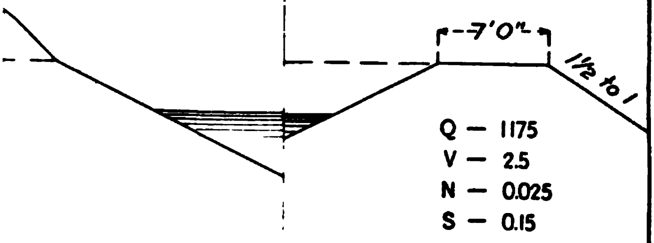
Division and work.	Quantity.	Orman & Crook, Pueblo, Colo.		Samuel Treais, Montrose, Colo.		Smith Bros., Montrose, Colo.		Knowlton & Bollen Construction Co., Fort Collins, Colo.		William S. Henderson, Montrose, Colo.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Division 18:											
Excavation—											
Class 1 .... cubic yards..	9,000	$0.14	$1,260.00	....	....	....	....	$0.18	$1,620.00	....	....
Class 2 .... do....	6,000	.30	1,800.00	....	....	....	....	.35	2,100.00	....	....
Class 3 .... do....	13,000	.36	4,680.00	....	....	....	....	.45	5,850.00	....	....
Class 4 .... do....	10,000	.75	7,500.00	....	....	....	....	.95	9,500.00	....	....
Overhaul .... do....	2,000	.02	40.00	....	....	....	....	.02	40.00	....	....
Refilling .... do....	1,200	.50	600.00	....	....	....	....	.50	600.00	....	....
Paving .... square yards..	1,500	2.25	3,375.00	....	....	....	....	2.00	3,000.00	....	....
Dry rubble masonry .... cubic yards..	700	5.50	3,850.00	....	....	....	....	6.00	4,200.00	....	....
Concrete—											
Class 1 .... do....	1,400	9.00	12,600.00	....	....	....	....	11.00	15,400.00	....	....
Class 2 .... do....	700	7.50	5,250.00	....	....	....	....	8.00	5,600.00	....	....
Laying pipe, 24-inch .... linear feet..	200	1.75	350.00	....	....	....	....	.88	176.00	....	....
Total	....	....	41,305.00	....	....	....	....	....	48,086.00	....	....
Division 19:											
Excavation—											
Class 1 .... cubic yards..	11,000	.14½	1,595.00	....	....	....	....	....	....	....	....
Class 2 .... do....	6,000	.30	1,800.00	....	....	....	....	....	....	....	....
Class 3 .... do....	18,000	.37	6,660.00	....	....	....	....	....	....	....	....
Class 4 .... do....	10,000	.75	7,500.00	....	....	....	....	....	....	....	....
Overhaul .... do....	30,000	.02	600.00	....	....	....	....	....	....	....	....
Refilling .... do....	100	.50	50.00	....	....	....	....	....	....	....	....
Dry rubble masonry .... do....	200	5.00	1,000.00	....	....	....	....	....	....	....	....

Concrete—											
Class 1 . . . do	1,100	9.00	9,900.00								
Class 2 . . . do	50	7.50	375.00								
Total			29,480.00								
Division 20:											
Excavation—											
Class 1 . . . cubic yards	15,000	.14	2,100.00					$0.24	$3,600.00		
Class 2 . . . do	5,000	.30	1,500.00					.30	1,500.00		
Class 3 . . . do	9,000	.37	3,330.00					.45	4,050.00		
Class 4 . . . do	5,000	.70	3,500.00					.95	4,750.00		
Overhaul . . . do	3,000	.02	60.00					.02	60.00		
Refilling . . . do	200	.50	100.00					.50	100.00		
Paving . . . square yards	900	2.00	1,800.00					2.00	1,800.00		
Dry rubble masonry . . . cubic yards	50	5.00	250.00					6.00	300.00		
Concrete—											
Class 1 . . . do	700	8.00	5,600.00					10.00	7,000.00		
Class 2 . . . do	20	7.00	140.00					8.00	160.00		
Laying pipe, 24-inch . . . linear feet	300	1.75	525.00					.88	264.00		
Total			18,905.00						23,584.00		
Division 21:											
Excavation—											
Class 1 . . . cubic yards	50,000	.14	7,000.00			$0.14	$7,000.00	.18	9,000.00		
Class 2 . . . do	18,000	.30	5,400.00			.25	4,500.00	.30	5.400.00		
Class 3 . . . do	35,000	.37	12,950.00			.40	14,000,00	.45	15,750.00		
Class 4 . . . do	10,000	.70	7,000.00			.90	9,000.00	.95	9,500.00		
Overhaul . . . do	10,000	.02	200.00			.02	200.00	.02	200.00		
Refilling . . . do	200	.50	100.00			.75	150.00	.50	100.00		
Paving . . . square yards	400	2.00	800.00			1.25	500.00	1.75	700.00		
Dry rubble masonry . . . cubic yards	50	4.50	225.00			.75	37.50	6.00	300.00		
Concrete—											
Class 1 . . . do	50	8.00	400.00			5.00	250.00	10.00	500.00		
Class 2 . . . do	50	7.00	350.00			5.00	250.00	8.00	400.00		

Bids on South canal, Uncompahgre Valley project—Continued.

Division and work.	Quantity.	Orman & Crook, Pueblo, Colo.		Samuel Treais, Montrose, Colo.		Smith Bros., Montrose, Colo.		Knowlton & Bollen Construction Co., Fort Collins, Colo.		William S. Henderson, Montrose, Colo.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Division 21—Continued.											
Laying pipe, 36-inch ... linear feet..	400	$2.00	$800.00	....	....	$0.25	$100.00	$0.88	$352.00	....	....
Laying pipe, 24-inch ... do....	200	1.75	350.00	....	....	.20	40.00	.60	120.00	....	....
Total......	....	....	35,575.00	....	....	....	36,027.50	....	42,322.00	....	....
Grand total......	....	....	513,365.00	....	....	....	....	....	....	....	....





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GUNNISON TUNNEL.

Under proposals received on October 5, 1904, a contract for the construction of the Gunnison tunnel was drawn with the Taylor-Moore Construction Company, of Hillsboro, Tex. This company experienced some difficulty in procuring an acceptable bond, but the contract was signed by the Secretary of the Interior in January, 1905. On January 11, 1905, the representatives of the company began work at the Cedar Creek portal of the tunnel. They carried on the work until May 27, on which date the contract was abandoned. The work was taken up by the officials of the Reclamation Service, and has since been carried on under their direct management.

On May 30, a cave-in occurred at the Cedar Creek end of the tunnel, by which six men were killed. The coroner's jury exonerated all persons from blame, and ascribed the accident to unforeseen and unavoidable conditions.

On September 26 proposals for the completion of the tunnel were received. Three bidders submitted proposals, which are shown below. All bids were rejected, and orders were given to complete the work under Government supervision.

Present conditions indicate that about 3,500 feet of the tunnel will be in soft ground, the remainder being in shale or harder rock. Under the Reclamation Service the power equipment has been brought to a fair state of efficiency, but some additional power installation must be made to bring the work to completion. It is estimated that power installation work can be completed by March 1, 1906.

Bids for Gunnison tunnel, Uncompahgre Valley project.

Tunnel.		J. G. White & Co., 43 Exchange place, New York City, N. Y.[a]		John McKechney & Co., 288 East Ohio street, Chicago, Ill.		A. J. Raisch, 26 Montgomery street, San Francisco, Cal.	
Kind of work.	Quantity.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
	Lin. ft.						
Class 1	11,500	$48.50	$557,750	$56.00	$644,000	$65.00	$747,500
Class 2	1,200	52.00	62,400	59.00	70,800	75.00	90,000
Class 3	10,000	62.75	627,500	53.59	535,900	85.00	850,000
Class 4	3,500	61.00	213,500	72.74	254,590	95.00	332,500
Lining with concrete the portion of tunnel already excavated:							
Class 1	1,500	9.00	13,500	4.00	6,000	12.00	18,000
Class 2	100	11.50	1,150	7.00	700	17.00	1,700
Class 3	1,400	12.50	17,500	13.68	19,152	17.00	23,800
Class 4	1,400	17.00	23,800	14.91	20,874	17.00	23,800
Excavation for enlarging tunnel section: Classes 1 and 2	*Cu. yds.* 3,000	8.00	24,000	7.00	21,000	12.00	36,000
Total			1,541,100		1,573,016		2,123,300

[a] Figures given by J. G. White & Co. are based only on receiving all of the contract.

WEST CANAL.

Plans are now complete for the construction of the West canal from Uncompahgre River to Coal Creek. On account of the prevailing high prices for contract work, it has been decided to postpone the letting of this work.

EAST CANAL.

Location surveys for the East canal were completed in the fall of 1904. Further work has been postponed until this canal can be taken up in the regular sequence of the work on the project.

HEADQUARTERS.

A building to be used as headquarters has been completed in Montrose, at a cost of approximately $5,000. The work was done by J. J. Kewin, of Montrose, Colo., under a contract dated June 28, 1905, proposals having been received on May 17, 1905. The heating plant for the building was furnished by the Montrose Hardware Company, of Montrose, Colo.

LATERAL SYSTEMS.

Some study of the problem of unifying existing water rights has been made, and negotiations for the purchase of the existing common carrier canals are now pending. The problem of lateral systems will be considered during the coming year.

The Water Users' Association has continued its organization, and has lent all necessary aid to the solution of such problems as have arisen from time to time.

STREAM MEASUREMENTS.

Gaging stations have been maintained throughout the year at three stations on the Uncompahgre River, at one station on the Cimarron River, at three stations on the Gunnison River, and at one station on the North Fork of the Gunnison River. During the coming year it is believed that stations may be relocated and a number of them abandoned, with a corresponding saving of time and money.

EXPENDITURES.

The total expenditures on the Uncompahgre Valley project to September 30, 1905, are as follows:

Expenditures on Uncompahgre Valley project to September 30, 1905.

Work.	Contractor.	Amount.	
South canal:			
Location surveys and engineering supervision		$40,000.00	
Excavation	Orman & Crook	33,509.85	
Do	Knowlton & Bollen	41,010.38	
Do	Kellog & Worley	8,878.64	$123,398.87
Gunnison tunnel:			
Engineering and supervision		15,000.00	
Materials		10,000.00	
Force account		80,000.00	
Construction	Taylor-Moore	18,890.05	123,890.05
Plant, including office supplies			90,000.00

Expenditures on Uncompahgre Valley project to September 30, 1905—Continued.

Work.	Contractor.	Amount.	
Tunnel road:			
Location and supervision		$5,000.00	
Force account		20,000.00	
			$25,000.00
Telephone	Ed A. Hess		5,641.60
Office building:			
Land in Montrose		450.00	
Construction	J. J. Kewin	1,262.72	
			1,712.72
Preliminary surveys, etc			65,000.00
Administration			19,401.04
Total			454,089.28

KREMMLING RESERVOIR SITE.[a]

One of the largest sites for the storage of irrigation water which has been under consideration by the Reclamation Service is the Kremmling reservoir site, on Grand River, named after the small town of Kremmling, Colo., in the lower portion of the basin. Over 1,000,000 acre-feet of water can be stored here by the construction of a dam about 180 feet high in what is known as Gore Canyon; and with a 230-foot dam the capacity would be nearly 2,200,000 acre-feet.

After a turbulent course as a mountain stream, through the chasms and narrow valleys of its upper watershed, Grand River emerges into this large, basin-like valley as a sluggish river, its quiet waters presenting a strange contrast to the torrents of its upper course. In its tortuous channel it winds through vast stretches of meadow lands, with scarcely a riffle for many miles, flowing in a general westerly direction toward the massive Gore or Park Range of mountains, there to disappear suddenly into the stupendous chasm known as Gore Canyon. Here the stream resumes its former torrential aspect. For 3½ miles, the length of Gore Canyon, its fall averages 100 feet to the mile. Below this canyon the river widens, and its fall becomes more normal.

Grand River receives the largest part of its water supply from the east side of Gore Range, which, during the dry months of the late summer and fall, contributes more run-off per square mile of drainage area than is derived by the river from the lower portions of its drainage basin. West of Gore Range notable tributaries are few and far apart; indeed, from Gore Canyon down to the mouth of Eagle River no large tributaries empty into Grand River. The consideration of water supply alone would indicate that the Kremmling reservoir site is most advantageously located for storing the most valuable portion of the water of Grand River. By providing proper storage facilities at the Kremmling site freshets will be prevented, and the water will be made available for use in the irrigating season.

After the waters of Gunnison River have been controlled by the irrigation works now under construction by the Federal Government, it will be possible, by building a high masonry dam in Gore Canyon, to conserve and regulate the flow of the entire Grand River from Gore Canyon down to its confluence with Green River. Even if feasible sites for dams exist either above the Kremmling site or below it, it is doubtful whether a dam constructed at any one of them would be as valuable in conserving and regulating the flow of

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[a] From report by G. H. Matthes.

Grand River as a dam at the Kremmling site. One advantageous feature of the Kremmling dam is that the river below the dam site flows for about 60 miles, or to the junction with Eagle River, through a canyon that contains only a few small ranches, which are not dependent on the waters of the Grand. This section of Grand River would be the main feeder for regulating the river farther down, and would therefore be subject to great fluctuations in flow. Yet these fluctuations would not be likely to work hardship on or interfere with any settlements or agricultural communities, as there are virtually none along this section of the river.

The section of Colorado which is tributary to the Kremmling site covers about 2,400 square miles, comprising not only the entire drainage of what is known as Middle Park or Grand County, but also that portion of Summit County that is drained by Blue River, and is characterized by a rough and mountainous topography, in part forest clad. The Park or Gore Range, with many peaks over 10,000 feet high, forms its western and southwestern boundaries, while the Continental Divide of the Rocky Mountains, with peaks ascending to elevations of 14,000 feet and over, forms the northern, eastern, and southern boundaries of the watershed. In this region the winters are long and severe, with heavy snowfalls during a period of six months. A certain amount of snow cover is retained by the high peaks throughout the summer months, the gradual melting of which insures the perennial flow of the limpid mountain streams and springs in which the region abounds.

The principal rivers draining directly into the proposed reservoir, in addition to Grand River proper, are Troublesome and Muddy creeks, which enter from the north, and Williams Fork and Blue River, which enter from the south. A study of the flow of these streams has been made for the last two years by maintaining gage records and measuring the discharge at stations on Grand River at the mouth of Gore Canyon; on Muddy Creek, near Kremmling, Colo.; on Blue River at the State bridge, about 15 miles above its mouth, and on Williams Fork, about 1½ miles above its mouth. In addition a number of regular gaging stations have been maintained on Grand River and its tributaries above the Kremmling reservoir site. From the records so kept it has been estimated that the annual flow into the proposed reservoir is over 1,000,000 acre-feet, the amount varying, of course, from year to year. The approximate inflow for the calendar year 1905, which appears to have been a normal year as regards rainfall and run-off in this section of Colorado, was 1,108,000 acre-feet.

A feature of the Kremmling site which is particularly favorable as compared with other storage reservoirs located on large rivers is the small amount of sediment contained in the waters that are to be stored in it. Only two of its tributaries carry fine material in suspension at all times—Muddy Creek, which receives the drainage of clay hills, and which, as its name indicates, has a muddy color, and Blue River, which, though a typical mountain stream, is discolored by the operation of placer mines near Breckenridge, Colo. The amount of silt which would be deposited in the reservoir by these two streams and from all sources at time of freshets is comparatively small, and would not seriously impair the value of the reservoir for generations to come. Regular daily observations of the amount of silt carried by Grand River are being made at the gaging station at the mouth of the canyon.

The Kremmling basin, when flooded, would in realty be a triple reservoir, extending up the valleys of Grand River proper and of two of its larger tributaries, Muddy Creek on the north and Blue River on the south, both streams emptying into the Grand a short distance above the mouth of Gore Canyon.

A site suitable for a high masonry dam has been found in Gore Canyon, about one-half mile below its entrance, at a point where the river flows between nearly vertical canyon walls. The river bottom here has an elevation above sea level of 7,270 feet. The river having a drop of about 30 feet between the dam site and the entrance to the canyon, the maximum depth in the main body of the reservoir, with a depth of water 180 feet at the dam, would be 150 feet. The top contour of the reservoir for this depth of water would be at elevation 7,450 feet. The area exposed to evaporation when the reservoir is full would be 15,805 acres, while the capacity would be 1,239,840 acre-feet. The site now occupied by the town of Kremmling would have 100 feet of water over it. The reservoir would be 150 miles in length from the dam to the point where Grand River would flow into it; the maximum width in its lower portion would be 3 miles, while the Muddy Creek and Blue River arms of the reservoir would be 9.5 miles and 8 miles in length, respectively.

During the summer of 1905 a plane-table survey of the Kremmling site, on a scale of 2,000 feet to 1 inch, with 20-foot contours, was made under the direction of Gerard H. Matthes, engineer, by J. C. Fitterer, assistant engineer, and M. I. Chapin, field assistant. The topography was sketched in up to the 7,500-foot contour, corresponding to a depth of water at the dam of 230 feet. The following table shows the capacity of the proposed reservoir, its area exposed to evaporation, and its mean depth, computed for each contour:

Table of areas, capacities, and mean depths of Kremmling reservoir site, Colorado.

Contours.	Areas exposed to evaporation.	Capacities between contours.	Total capacities.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
7,300	14.0	140.0	140.0
7,320	2,111.0	21,250.0	21,390.0
7,340	5,155.0	72,660.0	94,050.0
7,360	6,998.5	121,535.0	215,585.0
7,380	8,948.0	159,465.0	375,050.0
7,400	10,948.5	198,965.0	574,015.0
7,420	12,811.5	237,600.0	811,615.0
7,440	14,739.0	275,505.0	1,087,120.0
7,450	15,805.0	152,720.0	1,239,840.0
7,460	17,103.0	164,540.0	1,404,380.0
7,480	19,737.0	368,405.0	1,772,785.0
7,500	22,919.5	426,565.0	2,199.350.0

The major part of the area to be flooded consists of hay lands, which constitute the principal assets of the Middle Park ranchmen. Owing to the high altitude and short seasons other crops can not profitably be grown in this section. The amount of valuable hay lands which would be covered by the reservoir and which would constitute the principal item of cost, aside from that entailed by the construction of the dam, is roughly estimated at 10,000 acres. This includes the small town of Kremmling, Colo., which has a population of about 200, and the small settlement at Troublesome.

Borings with diamond drill were made during the fall of 1905 in Gore Canyon, to ascertain the depth to bed rock. The latter was found to consist, like the canyon walls themselves, of a dark-colored gneiss, intersected by white veins of quartz. The strata are tilted to a nearly vertical attitude, and in places the rock is schistose. The bed rock penetrated by the drill proved to be exceptionally sound, close grained, hard, and free from seams or cracks, The canyon walls, on the contrary, through ages of exposure to the elements, are rent by many fissures and cleavage planes, and in other ways give evidence of decay. It will be necessary to remove by blasting the unsound rock at the abutments for the dam.

The canyon in the first half mile from its mouth downstream offers at least four possible dam sites, all located within a distance of 1,000 feet. Of these the two upper afford good opportunities for constructing spillways on the left bank. The lower sites are located in the deeper portion of the canyon, where the abutments rise nearly vertically to a height of about 500 feet. Spillways at these sites can be provided only by tunneling through the canyon walls. The four sites possess practically the same dimensions, measuring about 150 feet across between canyon walls at the water level and about 350 feet across at the crest of the dam.

RESERVOIR SITES ON UPPER GRAND RIVER.[a]

GENERAL STATEMENT.

During the summer of 1905 a reconnaissance was made by Gerard H. Matthes, engineer, of the North and South forks of Grand River, Frazier River, Williams Fork, and Stillwater Creek in the upper portion of the basin of Grand River, in Colorado, for the purpose of locating reservoir sites on the headwaters of Grand River above the Kremmling reservoir site, a description of which is given on pages 121–124. The area drained by these streams is mountainous, the elevations of the valley bottoms exceeding 7,500 feet above sea level, while the peaks of the Continental Divide and of the Front Range of the Rocky Mountains, which form the northern and eastern boundaries of this basin, respectively, rise to elevations of from 10,000 to 14,000 feet or more.

The water resources of this section of the Rocky Mountains are among the finest in the United States, as a result of the deep snowfalls which occur here during six months of the year and the large amount of forest cover still remaining despite the ravages wrought by fire and ax.

The streams, which are of the torrential type, are fed by melting snows and innumerable deep-seated springs, and carry an abundance of clear, cold water. The high altitudes and short summer seasons have put a limit to the range of agricultural pursuits, rye and oats being among the few crops grown. The main industry, however, is cattle raising, while mining is as yet little developed. As large quantities of hay are annually required for feeding cattle during the winter months, the amount of hay raised by the ranchmen is considerable. Some irrigation water is required for this purpose, but the amount so diverted from the streams is comparatively small, and it is safe to say that no large amount of irrigation water will ever be used in this part of Grand County.

Few reservoir and dam sites worthy of investigation were encountered during the reconnaissance. As a rule, the conditions in this section of the Grand River basin are not favorable for impounding large volumes of water, principally on account of the rapid slopes of the valley floors, which exclude the possibility of securing large storage basins except with dams of unreasonable magnitude. Efforts were made to discover practicable sites below the confluences of important tributaries rather than along the tributaries themselves for reasons of adequacy of water supply. The sites so located and deemed worthy of investigation are the Windy Gap dam site below the confluence of Grand and Frazier rivers, and the Lehman dam site below the confluence of North and South forks of Grand River. A reconnaissance survey was also made to determine the possibility of water storage in Grand Lake by means of a project including the diversion of North Fork of Grand River into the lake.

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[a] From report by G. H. Matthes.

Information regarding the water resources for these reservoir sites was gained from a study of the results of stream measurements made at gaging stations, which have been maintained at the following points: Grand River, at Hot Sulphur Springs; Williams Fork, about 1½ miles above its mouth; Frazier River, near Granby; North Fork of Grand River, at a point 3 miles below Grand Lake; the outflow from Grand Lake, at the outlet; and North Inlet Creek, flowing into Grand Lake, at mouth.

WINDY GAP RESERVOIR SITE.

The dam site is located on Grand River, in sec. 27, T. 2 N., R. 77 W. A dam 90 feet high above the level of Grand River would backwater about 2½ miles, or above the confluence of Grand and Frazier rivers. A dam 135 feet high would create a reservoir extending up the valley of the Grand River for about 4 miles and up the valley of Frazier River for about 2 miles. A reservoir of this size would cover about 2,000 acres and have a probable capacity of 100,000 acre-feet. The abutments at the dam site are composed of a coarse conglomerate, the strata of which are tilted to a nearly vertical position. The right bank is a high, steep, rock wall, and the left bank consists of alternate slopes and vertical escarpments. The dam site is 275 feet across on the bottom, and the crest of a 135-foot dam will be about 650 feet long. A dam of greater height could be built at this site if deemed desirable. No evidence was found regarding the depth of bed rock at the dam site.

The combined flow of Grand and Frazier rivers would be more than ample to fill this reservoir, the discharge of Grand River at Hot Sulphur Springs, about 6 miles below the dam site, from March 1 to September 30, 1905, being 509,671 acre-feet.

The principal objection to this reservoir site lies in the fact that it is crossed throughout its length by the newly constructed line of the Denver, Northwestern and Pacific Railway. Other objectionable features are the large size of dam required and the fact that probably 75 per cent of the area flooded will consist of valuable hay and ranch lands.

LEHMAN RESERVOIR SITE.

A small reservoir site was discovered on Grand River, near Lehman post-office, in portions of secs. 1, 2, 11, and 12, T. 2 N., R. 76 W. and of secs. 6, 7, and 8, T. 2 N., R. 75 W. The dam site is located in sec. 11, T. 2 N., R. 76 W. A reconnaissance survey was made for a dam 96 feet high above the water level of Grand River at the dam site, making the elevation of the top contour 8,144 feet above sea level. In selecting this as the most economical height of dam, the general elevation of the surrounding low mesas was taken as a determining factor. The capacity of the reservoir when full is estimated at 24,000 acre-feet. The area to be flooded is about 800 acres and would cover valuable hay land to the extent of about 400 acres, including the ranch of C. N. King, or Lehman post-office, located in the lower part of the basin. Lines were found to have been surveyed for two private railroads, traversing the reservoir site for the better part of its length.

The dam site is at the entrance of a canyon, where the rock walls are composed of a pink granite of coarse texture, containing large quantities of mica. The right abutment is in the form of a steep cliff, while the left abutment is covered to a large extent with rock débris, revealing in places the solid ledge. The granite being badly disintegrated, the removal of considerable decayed rock will be necessary in order to obtain suitable abutments. The dam site is about 180 feet across on the bottom, and the crest of the dam would have a length of about 430 feet. There are no evidences that bed rock occurs near the surface. Sand suitable for building purposes may be had in small quantities near the dam site. The canyon was reconnoitered downstream for other dam sites, but presented no favorable places. On the contrary, the rapid fall of the river through the canyon made it undesirable to locate a dam further down the canyon and rendered it imperative to select a site as near the mouth as possible.

The streams draining into the reservoir site are the North and South forks of the Grand River, which join about 1 mile above the dam site, and Stillwater and Soda creeks. The reservoir would be about 30 feet deep at the confluence of the North and South forks and would extend only about 2,000 feet up the valley of North Fork, this stream having a very rapid fall. On the other hand, the South Fork, for several miles above the confluence, has but little fall, and meanders through vast stretches of level meadow lands, which would be flooded by the reservoir to a small depth, rendering the storage along this portion of the reservoir expensive as regards land damages and adding but little to the general capacity.

The flow into the reservoir is more than ample to fill it once a year, being 357,549 acre-feet between May 1 and September 30, 1905. No sediment is carried by the streams except at times of high water, practically the entire run-off being derived from springs and the melting of snow.

It is hardly necessary to point out that the disadvantageous features presented by the Lehman reservoir site more than outweigh the few favorable features which it otherwise possesses. The limited storage capacity and the comparatively large dam required alone suffice to condemn the site as undesirable for storage purposes. The poor quality of rock available for constructing the dam and the large amount of patented lands which would be flooded are further serious drawbacks.

GRAND LAKE.

Grand Lake is situated in the northwestern part of Grand County and occupies portions of secs. 4, 5, 6, 8, and 9, T. 3 N., R. 75 W. It covers an area of about 700 acres and has a maximum depth of 264 feet. Its drainage is into the North Fork of Grand River. It owes its existence to a long, narrow terminal moraine, which effectually bars a small valley inclosed by high mountains. The lake is extremely picturesque, and attracts many tourists every summer. The small town of Grand Lake is located on the northwest side of the lake, behind the moraine, and would not be affected by raising the surface of the lake from 20 to 25 feet above low-water level. A reconnaissance survey of the moraine and outlet of the lake discloses the fact that a dike 20 feet high across the outlet, and short dikes across a few gaps and small depressions in the moraine, is all that would be required for raising the level of the lake 20 feet for storage purposes. To store more than this depth of water would require considerable expenditure in building up the moraine to the required height, and also in increasing its width at numerous points in order that it may withstand the hydrostatic pressure. The moraine, which is nearly 1½ miles long, is composed of glacial débris, and is typically heterogeneous as regards materials, as is usually the case with formations of this kind. It is not likely that it will prove impervious under a high head of water.

The capacity of Grand Lake as a storage reservoir would be limited to the amount stored above its present low-water level. Soundings taken near the outlet show that the lake is shallow over a considerable area, and has a very sandy bottom. The depth of water near the outlet is about 3 feet at low water, and increases very gradually away from the shore for a distance of several hundred feet, beyond which the depth increases very rapidly. It appears to be impracticable to deepen the outlet in order to draw off more water, without involving great cost. The storage capacity with a 20-foot dam would therefore be limited to about 140,000 acre-feet. The outflow from the lake between April 1 and September 30, 1905, was 80,869 acre-feet, as computed from measurements of discharge made at the gaging station at the outlet of the lake. The principal tributaries to Grand Lake are North Inlet and East Inlet creeks. It is probable also that the lake receives considerable inflow from springs. A gage record is being maintained on North Inlet Creek by J. Cairns, voluntary observer, discharge measurements being made at regular intervals by employees of the Geological Survey.

Considered as a site for storing irrigation water for use along the lower Grand and Colorado rivers, Grand Lake, as will be readily seen from the foregoing, would be of little value. Not only is its storage capacity small, but it would not hold even the annual discharge of the streams draining into it, not to mention water supply from other sources.

It has been proposed to tap Grand Lake by means of a tunnel through the Front Range of the Rocky Mountains, and so divert its waters into Big Thompson River or St. Vrain Creek. From the best information available it appears that a tunnel of this kind would be about 12 miles long. Whether the value of the water so diverted to the east slope would warrant the expenditure involved in constructing a tunnel of this length is a matter which requires careful study and surveys. In connection with a project of this kind it has been proposed to divert the waters of North Fork of Grand River into Grand Lake. In order to ascertain the feasibility of the latter undertaking, lines of flying levels were run, connecting North Fork with Grand Lake, disclosing the fact that the North Fork at a point in sec. 36, T. 2 N., R. 76 W., about 1 mile from Grand Lake, is 288 feet higher than Grand Lake. The intervening topography, due to glacial action, is irregular. Separating the valley at Grand Lake from that of the North Fork, inclosed by moraines, lies a small lake known as Haberson Lake, located in sec. 36, T. 2 N., R. 76 W. Its elevation is 48 feet lower than that of North Fork at the point referred to above, and 240 feet higher than that of Grand Lake. The waters of North Fork could readily be diverted into Haberson Lake, and thence into Grand Lake, and it is probable also that a topographic survey will reveal a practicable canal route for diverting North Fork into North Inlet Creek. Should the plan of taking water to the east slope by means of a tunnel prove feasible, the storage on Grand Lake could then be utilized to good advantage as an equalizing reservoir, and a probable flow of about 640 second-feet could be delivered on the east slope throughout the entire irrigating season.

OPERATIONS IN IDAHO.

By D. W. Ross.

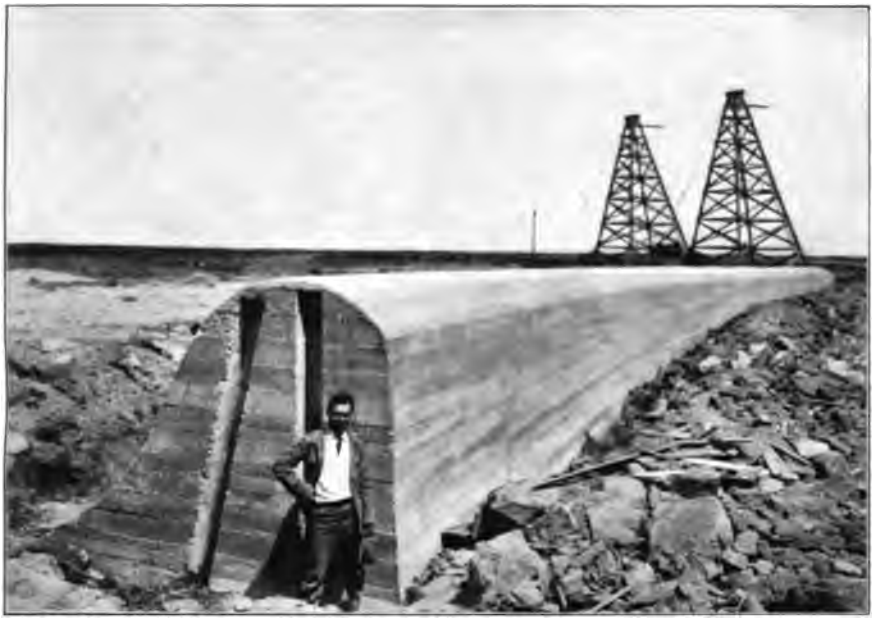
GENERAL CONDITIONS.

The construction work which was begun in December, 1904, on the Minidoka project has been steadily prosecuted during the season of 1905. In addition to the work in progress on the dam and spillway, contracts were let during July and August, 1905, for the construction of the main canals and distributing system; also for the construction of a telephone system. Work under these contracts is now in progress, provisions being made in the specifications for the completion of the entire gravity system of canals, which will irrigate about 80,000 acres of land, by June 1, 1906.

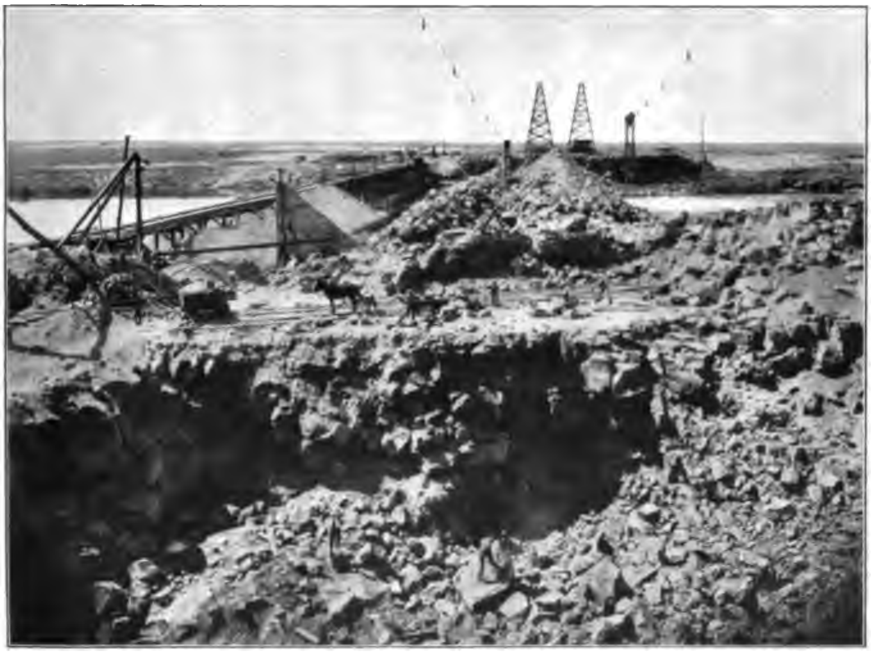
On February 15, 1905, a project board met at Boise for the consideration of plans and estimates in connection with the Payette-Boise project. Recommendations favoring the early construction of a portion of this project were made to the chief engineer, and in March, a favorable report having been made to the Secretary of the Interior, an allotment from the reclamation fund of $1,300,000 was ordered for the construction of a part of the Boise Valley division of this enterprise. During the present field season surveys of this portion of the project have been in progress, and plans and estimates are now being made preparatory to the letting of contracts at an early date. Negotiations for the use and control by the United States of the New York canal, which is to be enlarged and extended to form the main canal on the south side of Boise Valley, have been very satisfactorily concluded by the Reclamation Service. The Payette-Boise Water Users' Association has appraised the lands needed for right of way for the Deer Flat reservoir, and many contracts have been made by the owners for the sale of lands to the United States.

A general reconnaissance covering practically all the minor streams of the arid portion of the State has been concluded, and it is now thought that fairly accurate estimates can be made of the irrigation possibilities of practically every stream system.

The Second Annual Report of the Reclamation Service contained preliminary estimates of several projects in Idaho. In the case of the Minidoka project the probable cost of reclamation is fairly indicated by contract prices, only a comparatively small amount of work remaining to be done outside of these contracts. Detailed surveys lately made of the Payette-Boise project have suggested many changes in the plans originally proposed, and have led to an increase in the estimated cost of construction. Preliminary surveys and reconnaissance to determine the feasibility of storage works on the headwaters of Snake River were completed during the latter part of the field season of 1904. In some cases these conditions are almost ideal, but in others there will undoubtedly be found many difficult features. The great development now in progress in the Snake River Valley will lead to a demand for the construction of works to regulate the flow of this stream at an early date—much earlier than has generally been estimated.



A. SPILLWAY, MINIDOKA DAM, MINIDOKA PROJECT, IDAHO.



B. ROCK FILL AND CORE WALL FROM NORTH BANK, MINIDOKA DAM, MINIDOKA PROJECT, IDAHO.

MINIDOKA PROJECT.

DAM AND SPILLWAY.

The contract entered into by the Bates & Rogers Construction Company, dated September 17, 1904, provides for the construction of a dam in Snake River, spillway, head gates, and forebay canal, the work to be completed by December 17, 1905. The lowest bidder for this work having failed to comply with the requirements of the specifications, it became necessary to let the contract to the above-named company, whose bid was second in amount. Considerable delay occurred before the matter was finally adjusted, and owing to this and to delay in receiving the shipment of the construction plant and equipment the winter season was well advanced before work was fairly under headway, little work having been done before January, 1905. Since that time the work has been vigorously prosecuted, but owing to the fact that the work had to be carried forward in a certain sequence, and that in constructing certain portions only a comparatively small number of men could be employed, progress seemed at times to be slow. This was particularly noticeable when the core wall was being laid across the deep, narrow portion of the river channel; also when it became necessary to concentrate on the excavation of the narrow diversion channel. Owing to these causes it will not be possible for the contractors to finish this work within the time specified in their contract.

The dam, when completed, will consist of a heavy rock fill with a concrete core wall, faced on the upstream side with a heavy earth embankment. A spillway (Pl. XV, *A*), provided on the left bank of the river, is of ample capacity to carry the greatest possible flow of flood water without danger of overtopping the dam. The total length of the entire structure is 4,412 feet.

The rock fill (Pl. XV, *B*) is constructed of lava rocks ranging in size from a few cubic inches to 4 cubic yards or more in volume. The smaller ones fill the interstices between the larger ones, and in turn the interstices between the smaller rocks are sluiced full of gravel and sand, thus making the structure tight and securing the maximum weight. In filling the deep channel stones of not less than 2 tons in weight were used until the velocity of the water was checked, after which smaller ones were filled in. The stones decrease in size toward the upstream face of the rock fill, where small ones are used. The earth embankment joins the upstream face of the rock fill, and is composed of gravel and sand and faced with earth containing from 35 to 50 per cent of clay.

A concrete core wall extends across the river upstream from and parallel to the axis of the dam. This wall is founded on the solid rock bed of the river and serves as a cut-off to water that would otherwise follow along the bed of the river underneath the structure.

The spillway (Pl. XV, *A*) is constructed of concrete on a solid rock foundation, with an earth embankment along the upper face.

Around the northern end of the dam a channel is cut through a rock point to divert the entire flow of the river during the construction of the southern end of the dam. In this channel there is a concrete dam with regulating devices, below which it is proposed to build a water-power plant for the purpose of generating electric power to be used for pumping water onto tracts of land that lie above the gravity canal in Cassia County.

On beginning excavation here it was found that the cofferdam as constructed was totally inefficient in itself, and it became necessary to build a secondary cofferdam, inclosing an area just sufficient for the construction of the wall. Much difficulty was experienced in getting this one built, as water broke through a number of times, but finally this secondary cofferdam was made tight and the construction of this section of the core wall proceeded without serious interruption and was completed June 30. Owing to the loss of time in awarding the contract during the summer of 1904 this work was carried on during the high-water period, which rendered it more hazardous and difficult than it otherwise would have been, inasmuch as the difference between the high and low water discharge of the river was about 11,000 cubic feet per second.

Efforts are being concentrated toward the completion of the diversion channel and the concrete dam with regulating devices, as the early completion of the rock fill is dependent on this. Work is being vigorously prosecuted night and day. Cement for this work, all machinery, and supplies are hauled by teams from Minidoka, a distance of 6 miles.

MAIN CANALS AND DISTRIBUTING SYSTEM.

BIDS AND CONTRACTS.

A project board, consisting of the governor and state engineer of Idaho and engineers of the Reclamation Service, met at Boise February 15, 1905, and recommended that contracts be let for the immediate construction of the north side canal and lateral system. In view of the fact that the Reclamation Service had decided not to install a pumping system for the irrigation of the lands on the south side of the river for perhaps several years yet, it was recommended that a small canal be constructed on the south side of the river with a view to providing at once for the irrigation of the lands which could be reached by gravity. This recommendation was approved, and on April 20, 1905, bids were invited for the construction of a main canal and branches and distributaries on the north side of the Snake River, and of a canal on the south side; also for the construction of a telephone system.

In letting these contracts the work was divided into eight parts. Schedule 1 consisted of the north side main canal, which contained practically all the rockwork on the north side of the river; schedule 2 covered the canal on the south side; schedules 3, 4, and 5 covered divisions of the branch canals and distributaries on the north side; schedule 6 covered the waste canal on the north side; schedule 7, the head gates, turnouts, and bridges and other structures; while schedule 8 covered the gates and lifting devices.

The following table shows the bids received and the amounts for each bid:

Bids received on schedule 1, distribution system, Minidoka project, Idaho.

Work or material.	Quantity.	Orman & Crook, Pueblo, Colo.		Utah Construction Co., Salt Lake, Utah.	
		Unit price.	Amount.	Unit price.	Amount.
Excavation:					
Class 1 . . . . . . cubic yards. .	417,400	$0.14	$58,436.00	$0.15	$62,610.00
Class 2 . . . . . . do. . . .	5,000	.30	1,500.00	.40	2,000.00
Class 3 . . . . . . do. . . .	32,600	.36	11,736.00	.50	16,300.00
Class 4 . . . . . . do. . . .	105,800	.95	100,510.00	1.10	116,380.00
Riprap . . . . . . do. . . .	12,160	1.33	16,172.80	1.00	12,160.00
Overhaul . . . . . . do. . . .	28,900	.01½	433.50	.02	578.00
Total	. . . . . .	. . . . . .	188,788.30	. . . . . .	210,028.00

Work or material.	Kilpatrick Bros. & Collins, Beatrice, Nebr.		Griffiths & McDermott, Chicago, Ill.		Bates & Rogers Construction Co., Chicago Ill.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:						
Class 1	$0.16	$66,784.00	$0.15	$62,610.00	$0.15	$62,610.00
Class 2	.30	1,500.00	.37	1,850.00	.90	4,500.00
Class 3	.45	14,670.00	.40	13,040.00	1.43	46,618.00
Class 4	1.10	116,380.00	1.23	130,134.00	1.43	151,294.00
Riprap	1.50	18,240.00	1.35	16,416.00	2.50	30,400.00
Overhaul	.01	289.00	.01½	433.50	.02	578.00
Total	. . . . . .	217,863.00	. . . . . .	224,483.50	. . . . . .	296,000.00

Bids received on schedule 2, distribution system, Minidoka project, Idaho.

Work or material.	Quantity.	Orman & Crook, Pueblo, Colo.		Utah Construction Co., Salt Lake, Utah.		Kilpatrick Bros. & Collins, Beatrice, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:							
Class 1.......cubic yards..	977,700	$0.12½	$122,212.50	$0.13	$127,101.00	$0.16	$156,432.00
Class 2..............do....	5,950	.27	1,606.50	.40	2,380.00	.30	1,785.00
Overhaul...............do....	238,400	.01½	3,576.00	.02	4,768.00	.01	2,384.00
Total..................	....	....	127,395.00	....	134,249.00	....	160,601.00

Work or material.	Griffiths & McDermott, Chicago, Ill.		Hubbard & Carlson, Boise, Idaho.		Nelson Rich, Prosser, Wash.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:						
Class 1.............................	$0.124	$121,234.80	$0.12	$117,324.00	$0.15	$146,655.00
Class 2.............................	.37	2,201.50	.20	1,190.00	.20	1,190.00
Overhaul.............................	.01¼	2,980.00	.01¼	2,980.00	.01	2,384.00
Total.............................	....	126,416.30	....	121,494.00	....	150,229.00

Bids received on schedule 3, distribution system, Minidoka project, Idaho.

Work or material.	Quantity.	Orman & Crook, Pueblo, Colo.		Utah Construction Co., Salt Lake, Utah.		Kilpatrick Bros. & Collins, Beatrice, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:							
Class 1.......cubic yards..	1,239,500	$0.12¼	$151,838.75	$0.13½	$167,332.50	$0.16	$198,320.00
Class 2..............do....	13,800	.27	3,726.00	.40	5,520.00	.30	4,140.00
Class 4..............do....	2,100	.95	1,995.00	1.30	2,730.00	1.10	2,310.00
Overhaul...............do....	166,100	.01½	2,491.50	.02	3,322.00	.01	1,661.00
Total..................	....	....	160,051.25	....	178,904.50	....	206,431.00

Work or material.	Griffiths & McDermott, Chicago, Ill.		W. H. Philbrick and J. E. Hilton, American Falls, Idaho.		Monarch & Porter, Des Moines, Iowa.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:						
Class 1.............................	$0.124	$153,698.00	$0.13	$161,135.00	$0.104	$128,908.00
Class 2.............................	.37	5,106.00	.50	6,900.00	.35	4,830.00
Class 4.............................	1.40	2,940.00	1.50	3,150.00	.85	1,785.00
Overhaul.............................	.01½	2,491.50	.02	3,322.00	.01	1,661.00
Total.............................	....	164,235.50	....	174,507.00	....	137,184.00

Bids received on schedule 4, distribution system, Minidoka project, Idaho.

Work or material	Quantity.	Orman & Crook, Pueblo, Colo.		Utah Construction Co., Salt Lake, Utah.		Kilpatrick Bros. & Collins, Beatrice, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:							
Class 1.......cubic yards..	570,750	$0.12¼	$69,916.87	$0.13	$74,197.50	$0.16	$91,320.00
Class 2..............do....	8,100	.27	2,187.00	.35	2,835.00	.30	2,430.00
Overhaul...............do....	172,800	.01½	2,592.00	.02	3,456.00	.01	1,728.00
Total..................	....	....	74,695.87	....	80,488.50	....	95,478.00

Work or material.	Griffiths & McDermott, Chicago, Ill.		Conway, Wilhite & Ryberg, Boise, Idaho.		Davidson & Tautphaus, Twin Falls, Idaho.		Monarch & Porter, Des Moines, Iowa.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:								
Class 1......................	$0.13½	$77,051.25	$0.14	$79,905.00	$0.13	$74,197.50	$0.093	$53,079.75
Class 2......................	.37	2,997.00	.45	3,645.00	.13	1,053.00	.35	2,835.00
Overhaul......................	.01½	2,592.00	.01½	2,592.00	.02	3,456.00	.01	1,728.00
Total..................	......	82,640.25	......	86,142.00	......	78,706.50	....	57,642.75

Bids received on schedule 5, distribution system, Minidoka project, Idaho.

Work or material.	Quantity.	Orman & Crook, Pueblo, Colo.		Utah Construction Co., Salt Lake, Utah.		Kilpatrick Bros. & Collins, Beatrice, Nebr.		Griffiths & McDermott, Chicago, Ill.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:									
Class 1.cubic yards..	175,400	$0.12¼	$21,486.50	$0.13	$22,802.00	$0.20	$35,080.00	$0.13½	$23,679.00
Overhaul.........do....	6,000	.01½	90.00	.02	120.00	.02	120.00	.01½	90.00
Total.............	....	......	21,576.50	......	22,922.00	......	35,200.00	......	23,769.00

Work or material.	W. H. Philbrick and J. E. Hilton, American Falls, Idaho.		Gen. Ray Hardisty, Minidoka, Idaho.		Davidson & Tautphaus, Twin Falls, Idaho.		Nelson Rich, Prosser, Wash.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:								
Class 1......................	$0.13	$22,802.00	$0.13⅞	$24,336.75	$0.13	$22,802.00	$0.13	$22,802.00
Overhaul......................	.01	60.00	.01½	90.00	.02	120.00	.01	60.00
Total..................	......	22,862.00	......	24,426.75	......	22,922.00	....	22,862.00

Bids received on schedule 6, distribution system, Minidoka project, Idaho.

Work or material.	Quantity.	Orman & Crook, Pueblo, Colo.		Utah Construction Co., Salt Lake, Utah.	
		Unit price.	Amount.	Unit price.	Amount.
Excavation:					
Class 1 .... cubic yards..	323,000	$0.14	$45,220.00	$0.15	$48,450.00
Class 2 .... do....	5,000	.35	1,750.00	.40	2,000.00
Class 3 .... do....	10,000	.37	3,700.00	.50	5,000.00
Class 4 .... do....	65,000	.97	63,050.00	1.25	81,250.00
Overhaul .... do....	20,000	.01½	300.00	.02	400.00
Total	....	....	114,020.00	....	137,100.00

Work or material.	Kilpatrick Bros. & Collins, Beatrice, Nebr.		Griffiths & McDermott, Chicago, Ill.		Hubbard & Carlson, Boise, Idaho.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:						
Class 1	$0.17	$54,910.00	$0.18	$58,140.00	$0.15	$48,450.00
Class 2	.30	1,500.00	.43	2,150.00	.30	1,500.00
Class 3	.45	4,500.00	.43	4,300.00	.40	4,000.00
Class 4	1.10	71,500.00	1.40	91,000.00	1.20	78,000.00
Overhaul	.01	200.00	.01½	300.00	.01¼	250.00
Total	....	132,610.00	....	155,890.00	....	132,200.00

Bids received on schedule 7, distribution system, Minidoka project, Idaho.

BRIDGES AND STRUCTURES, MAIN NORTH-SIDE CANAL.

Work or material.	Quantity.	Orman & Crook, Pueblo, Colo.	
		Unit price.	Amount.
Four bridges:			
Concrete .... cubic yards..	160	$5.50	$880.00
Steel .... pounds..	2,700	.07½	202.50
Clear lumber .... feet B. M. Oregon fir..	19,260	41.00	789.66
Common lumber .... feet B. M. pine..	20,060	39.00	782.34
Waste way:			
Concrete .... cubic yards..	270	6.00	1,620.00
Steel .... pounds..	4,800	.07½	360.00
Headgates south-side canal:			
Concrete .... cubic yards..	250	6.75	1,687.50
Steel .... pounds..	7,000	.07½	525.00
Total	....	....	6,847.00

Bids received on schedule 7, distribution system, Minidoka project, Idaho—Continued.

BRIDGES AND STRUCTURES, BRANCH A.

Work or material.	Quantity.	Orman & Crook, Pueblo, Colo.	
		Unit price.	Amount.
Six bridges:			
Concrete .... cubic yards..	82	$5.50	$451.00
Steel .... pounds..	1,900	.07½	142.50
Clear lumber .... feet Oregon fir..	11,070	41.00	453.87
Common lumber .... feet pine..	12,640	39.00	492.96
Six turn-outs:			
Concrete .... cubic yards..	324	6.25	2,025.00
Steel .... pounds..	11,800	.07½	885.00
Common lumber .... feet Oregon fir..	220	39.00	8.58
Total	....	....	4,458.91

BRIDGES AND STRUCTURES, BRANCH B.

Work or material.	Quantity.	Unit price.	Amount.
Seven bridges:			
Concrete .... cubic yards..	140	$5.75	$805.00
Steel .... pounds..	2,450	.07½	183.75
Clear lumber .... feet Oregon fir..	14,090	41.00	577.69
Common lumber .... feet pine..	18,620	39.00	728.91
Siphon:			
Concrete .... cubic yards..	260	6.75	1,755.00
Steel .... pounds..	1,200	.07½	90.00
Turn-outs:			
Concrete .... cubic yards..	170	6.50	1,105.00
Steel .... pounds..	4,200	.07½	315.00
Common lumber .... feet pine..	70	39.00	2.73
Total	....	....	5,563.08

BRIDGES AND STRUCTURES, BRANCH C.

Work or material.	Quantity.	Unit price.	Amount.
Three bridges:			
Concrete .... cubic yards..	60	$5.75	$345.00
Steel .... pounds..	800	.07½	60.00
Common lumber .... feet pine..	6,670	39.00	260.13
Turn-outs:			
Concrete .... cubic yards..	140	6.50	910.00
Steel .... pounds..	5,151	.07½	386.25
Common lumber .... feet pine..	200	39.00	7.80
Total	....	....	1,969.18

BRIDGES AND STRUCTURES, MAIN SOUTH-SIDE CANAL.

Work or material.	Quantity.	Unit price.	Amount.
Thirteen bridges:			
Clear lumber .... feet Oregon fir..	42,250	$41.00	$1,732.25
Common lumber .... feet pine..	57,200	39.00	2,230.80
Concrete .... cubic yards..	520	5.75	2,990.00
Steel .... pounds..	2,000	.07½	150.00

Bids received on schedule 7, distribution system, Minidoka project, Idaho—Continued.

BRIDGES AND STRUCTURES, MAIN SOUTH-SIDE CANAL—Continued.

Work or material.	Quantity.	Orman & Crook, Pueblo, Colo.	
		Unit price.	Amount.
Turn-outs:			
Concrete .... cubic yards..	260	$6.75	$1,755.00
Steel .... pounds..	1,000	.07½	75.00
Cast iron .... do....	21,000	.07½	1,575.00
Lumber .... feet pine..	28,000	39.00	1,092.00
Total	....	....	11,600.05
Total schedule 7	....	....	30,438.22

Bids received on schedule 8, distribution system, Minidoka project, Idaho.

Work or material.	Quantity.	United Iron Works, Oakland, Cal.		Vulcan Iron Works, Chicago, Ill.	
		Unit price.	Amount.	Unit price.	Amount.
Seventeen gates and guides, cast iron...pounds..	48,800	$0.07½	$3,393.00	$0.0516	$2,414.88
Sixty-four gates, steel .... do....	15,400	.10½	1,617.00	.10095	1,554.63
Eighty-one lifting devices:					
Sixty-two wrench devices	....	54.00	3,348.00	36.46	2,260.52
Two standard devices	....	185.00	370.00	62.27	124.54
Seventeen pedestal devices	....	200.00	3,400.00	183.33	3,116.61
Total	....	....	12,128.00	....	9,471.18

The grading contracts provide that all work shall be completed by June 1, 1906. The telephone system is to be completed ninety days from the date of notification of the approval of the contract, which is October 18, 1905.

Work under these contracts was begun early in July, or almost immediately upon approval of the bids by the Secretary of the Interior, and has been vigorously prosecuted since that time.

MAIN SOUTH-SIDE CANAL.

The canal on the south side of the river now being constructed extends from the point of diversion at the south end of the spillway to the site selected for the pumping stations, a distance of 13 miles. This canal will have a capacity of 100 second-feet. It is designed with a view to enlarging it at some future time to a capacity of 800 second-feet. It is 20 feet wide on the bottom, with side slopes of 2 to 1. In thorough fills, which occur at a few places, it is 46 feet wide on the bottom, the banks being of full dimensions as for the enlarged canal. In shallow cuttings a berm is left on the inside, so as to admit of enlarging to a full bottom width of 46 feet at a minimum expense. This canal will have a capacity of 1 second-foot for each 80 acres of land and will irrigate about 8,000 acres by gravity.

MAIN NORTH-SIDE CANAL.

The first 9,000 feet of the main north-side canal is mostly in solid rock. It is 30 feet wide on the bottom, has side slopes varying from ½ to 1 to 1 to 1, and will carry water to a depth of 10 feet. The canal will drop 12 feet near the end of the rock cut, from which point, for a distance of about 5 miles, or at the crossing of the Minidoka and Southwestern

Railway, it will be mostly in earth, with a bottom width of 46 feet, inside slopes 3 to 1, outside slopes 2 to 1, to carry 7.5 feet of water. The banks will be 10 feet high and 8 feet wide on top. Immediately above the crossing of the Minidoka and Southwestern Railway the canal will be divided into two branches, the "A" branch leading to the south, watering lands situated south and east of the railway, and the "B" branch, which crosses the railroad, taking a southwesterly course, parallel to the railroad right of way, to Snake River, a distance of about 13 miles. This branch is carried underneath the railroad in an inverted siphon, consisting of 5 arched openings with a regulating gate at the upper end of each opening.

The capacity of the main canal near the upper end is 1,200 second-feet, or 1 second-foot for each 60 acres of land to be irrigated. The "A" branch will have a capacity of 423 and the "B" branch 639 second-feet. These branch canals are each subdivided into several smaller branches,[a] with capacities varying from 60 to 200 second-feet, the capacities provided being at the rate of 1 second-foot for each 60 acres for branches discharging from 100 second-feet up; 1 second-foot for each 50 acres for branches discharging from 25 to 100 second-feet, and 1 second-foot for each 40 acres for branches with less than 25 second-feet discharge. No sublateral or farm-unit laterals will have a capacity less than 4 second-feet.

The north-side tract being exceedingly level, it was very difficult to get sufficient grade for the lateral system, nearly all the branches and laterals being located on a grade of 1 foot to 5,000 feet. In order to provide for the irrigation of all the land adjacent to these ditches, the water surface had to be kept well above the level of the ground—from 2 to 3 feet in most places. This necessitated considerable borrow in the construction of the canals, and advantage was taken of this feature in fixing the capacities of the various branches, since the cost of construction would be practically the same whether the banks were set far apart or close together. The porous nature of the soil and the almost entire absence of surface slope will probably render necessary the use of large irrigation heads, while it is safe to predict considerable loss of water in the canals. For these reasons it was thought best to provide abundant capacities for the main canals and laterals, also for the farm-unit laterals for which large heads will have to be conducted under a system of rotation.

The land under the gravity canal on the south side of the river lies in a narrow strip. It has considerable surface slope and could easily be irrigated by a system of comparatively short laterals. About 72,000 acres can be irrigated by the gravity system on the north side of the river and about 8,000 on the south.

All of the principal structures in the main canal and branches will be of masonry. Owing to the fact that the water surface in the main canals and laterals will have to be kept well above the surface of the ground in order readily to provide for the irrigation of the adjacent lands, checks will be placed at intervals, in most cases just below lateral head gates, for the purpose of regulating the depth of water. When the canal is operated at its full capacity many of these checks will probably not be needed, but since the canal will not likely be run full for several years it was necessary to make immediate provisvision for this regulation.

The inside slopes of all canals in earth on the north side will be 3 to 1, the outside slope being 2 to 1, the width of the banks on all the principal canals being not less than 8 feet and on the smaller laterals 6 feet. All banks will be carried 2 feet above the water surface in the canal. In constructing these canals no runways are allowed on the inside slopes, the material excavated between the banks being hauled up the slope, the tramping thus being evenly distributed over all parts of the bank.

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[a] See Pl. XX, Third Annual Report Reclamation Service, general map, Minidoka project.

TELEPHONE SYSTEM.

The following bids for the construction of a telephone system were opened:

Bids for construction of telephone system.

No.	Bidder.	Section 1.		Section 2.	Total for schedules 1 and 2.
		Price per mile.	Total.	Total price.	
1	W. H. Crumb & Co., Chicago, Ill.	$347.50	$6,255.00	[a]$80.00	$6,335.00
2	John Riddle, Boise, Idaho	360.00	6,480.00	220.00	6,700.00
3	W. I. Thrailkill, Boise, Idaho	374.43	6,739.74	172.00	6,911.74
4	Berggren Electric Co., St. Paul, Minn.	475.00	8,550.00	345.00	8,895.00
5	Rocky Mountain Bell Telephone Co., Salt Lake City, Utah	625.00	11,250.00	100.00	11,350.00

[a] $380, if not awarded section 1.

A recommendation was made that the bid of W. H. Crumb & Co. for the construction of this telephone system be accepted and contract awarded.

DOMESTIC WATER SUPPLY.

When bids were invited for the construction of the main canals and distributing system there were but few settlers on the lands and practically no efforts had been made to procure water from wells, many of the settlers being at that time compelled to haul water from the river a distance of from 2 to 6 miles. Believing that a considerable saving could be made in the cost of constructing these canals if a water supply for domestic purposes could be obtained in wells at different points on the tract, the Reclamation Service decided to make borings for that purpose. Accordingly, 10 wells were sunk at different points on the north side of the river, an effort being made to locate them where they would be of service to the contractors during the construction period. An excellent supply of water was found in every case at a depth of from 70 to 125 feet below the surface. These holes were provided with 2½-inch casings, with a pump cylinder, and screened well points at the bottom of each. As soon as it was discovered that water could be procured at reasonable depth many of the settlers drilled similar wells, so that when the intending bidders looked over the line of the canals they found that an abundant supply of water for stock and domestic purposes could be procured at almost any point at very reasonable expense. Several of the contractors have appropriated these Government wells, having attached pumps driven by gasoline engines to them. It is thought that the comparatively small outlay was fully justified, and perhaps has effected a large saving in the cost of the canals.

EXPENDITURES.

The expenditures on the Minidoka project to September 30, 1905, were as follows:

Expenditures on Minidoka project to September 30, 1905.

Work.	Contractor.	Amount.	
Diversion dam, spillway, etc.:			
Construction	Bates & Rogers	$109,035.72	
Cement	Portland Cement Co., of Utah.	10,777.80	
			$119,813.52
Main north-side canal: Excavation	Orman & Crook		3,661.75
Main south-side canal: Excavation	do		11,888.23
Distributing system:			
Excavation	do	4,948.41	
Do	Hubbard & Carlson	11,593.25	
Do	Monarch & Porter	4,315.92	
			20,857.58
Reservoir: Purchase of lands			15,060.00
Engineering, design, and supervision			59,000.00
Preliminary surveys, stream gaging, etc			34,000.00
Administration, etc			8,005.19
Total			272,286.27

SETTLEMENT OF LANDS AND TOWN SITES.

In May, 1904, just before the approval by the Secretary of the project, practically none of the lands under the proposed system were entered. As soon at the public announcement of the approval was made there was a rush by home seekers, and in a very few months practically every farm unit was entered. Many of these entries were no doubt speculative and many of the entry men will probably fail to comply with the requirements of the homestead law, but the number of contest notices which have been regularly published during the latter part of the present season stands as evidence of the value attached to this land by the home seeker, and it is extremely doubtful if a single tract that can be irrigated will go begging. Practically every farm unit under the gravity system of canals is located, and many tracts above the gravity system have also been entered. About 1,000 farm units, averaging a little less than 80 acres each, are situated under the gravity system and will receive water during the latter part of the season of 1906.

Three tracts, situated on the line of the Minidoka and Southwestern Railway north of Snake River, were reserved for town-site purposes. These sites are now being surveyed under the direction of the United States General Land Office, and it is expected that the lots will soon be advertised for sale. Sidings have been constructed at all of these points by the Oregon Short Line Railway Company and stations established. In response to the demand for stores and other facilities, many business men have already located at these points, although no title of any kind can be secured to the lots, upon which have been erected many substantial buildings. Churches and schools have already been established at these prospective centers of population.

SOIL AND DRAINAGE OF MINIDOKA LANDS.

SOILS NORTH OF RIVER.

As before stated, the lands on the north side of Snake River are extremely flat—so flat that proper gradients can with difficulty be obtained, in places, for the distributing canals without subdrainage or some other effective means of disposing of the waste water. Ordinarily this condition of the surface might prove a serious drawback. Many tests were made of the subsoil before the approval of the project—enough to indicate that subdrainage could be secured—but it was decided to make a thorough examination of soil conditions, and a careful survey was accordingly made during the spring of 1905.

GENERAL CHARACTER.

Nearly all the irrigable land is situated in a broad, level plain, which lacks salient topographic features. Knobs and ridges occur here and there, and near the river there is a belt of low sand dunes, which nowhere rises higher than 10 feet above the level of the surrounding country. There are also shallow depressions and several well-marked continuous swales. The land slopes generally southwestward rather than toward the river.

The soils present considerable variation in character and texture, but may be divided into the following types: (1) A medium to fine-textured sandy loam, which often contains considerable gravel, and is underlain by a light subsoil; (2) a very light to loose sandy loam that is underlain by a subsoil of heavy material; (3) a brown, rather heavy loam; (4) a dark-brown or black sticky clay loam or alluvium. The first two are very similar in character, but the heavier soil is underlain by a stratum of heavy material that will give it, under irrigation, qualities not possessed by the higher type.

The heavier sandy loam of the type first named above lies in the middle and southern portions of the area. At a depth of about 2 feet the soil changes to a light yellow or nearly white compact material composed of silt or very fine sandy loam.

The second type of soil, a medium to fine textured, loose, sandy loam, in which fine gravel is often present in considerable quantities, is composed of particles of crystalline rock, quartz predominating, but a sufficient amount of basic minerals is present to give it a rather dark color when moist. The gravel is mainly lava (basalt), though pebbles of granite, quartzite, and other rocks are also found. The soil varies in the amount of loam it contains; the low knolls are often little more than pure sand, while in the depressions the soil may show considerable coherence, due to the presence of finer particles. It is probable that after several years of irrigation this soil will become more loamy by the breaking down of its constituents and the addition of small quantities of silt in the irrigation waters. At a depth varying from 2 to 3 feet is a subsoil of clean sand and fine gravel. In many places a stratum of partly cemented sand, 6 or 8 inches thick, separates the sandy loam soil and the subsoil of pure sand. This stratum is never sufficiently indurated to act as a true hardpan, however, and water has little difficulty in passing through it. The sand and gravel of the deeper layers possess peculiar characteristics, which make them an important factor in determining the future development of agriculture under irrigation. They form the substratum of the entire terrace on the north side of the river, underlying not only this type, but the others as well. This substratum is so loose and incoherent that in digging wells curbing is always necessary to prevent it from caving, and even where curbing is used it causes considerable trouble, for it contains hardly any silt or clay to give it cohesion. Material of this character takes up moisture very rapidly; water poured upon it sinks almost immediately out of sight. The average thickness of these pervious beds, as computed from the records of wells dug or drilled within the tract, is about 25 feet, but varies from 4 or 5 to nearly 40 feet.

This lightest type of soil occupies level, generally smooth land, on which expensive leveling will not be necessary, though better results will probably be obtained if the surface is made uniformly as smooth as possible before irrigation is begun. This kind of soil is found in the northeastern part of the project, occupying a little more than one-third of the total area. It seems to be entirely free from alkali and no trouble is expected from the accumulation of harmful quantities of these salts. Though the surface has little natural slope, the soil, on account of its texture and the pervious beds of sand underlying it, should be naturally well drained.

The light, sandy loams are especially adapted to grow potatoes and other vegetables, small fruits, and alfalfa. Oats also will do well on them, and wheat can be grown with success, although this is generally thought to give better returns on heavier soils. Sugar beets and melons are also adapted to the conditions of the soil here.

The other type of sandy loam lies in the middle and southern portion of the area. It is about equal in extent to the type above described, which it resembles in many respects. The soil proper varies from a very light, loose, sandy loam to a heavy sandy loam or loam, the lighter phase predominating. At a depth of about 2 feet the soil changes to a light yellow or nearly white compact material composed of silt or very fine sandy loam. This stratum is 2 or 3 feet thick and is underlain, generally at a depth of 4 feet, by the same stratum of loose-textured clean sand that is found under the type previously described. This stratum of heavier material in the subsoil is that which distinguishes it from the other sandy soils, rendering it more retentive of moisture. It seems to be rich in lime and occasionally is partially cemented and difficult to dig through. It is not, however, impervious to water, as was shown by several experiments. Moisture soon soaks into it, and where it is turned up to the surface it soon crumbles down into powdery material.

This soil is generally free from alkali. In some localities, notably in the southern portion of the area near the river, a small amount of these salts is found in the silty subsoil. But in only one or two cases did tests show more than 6 per cent of soluble material as an average for the first 6 feet. The highest test was obtained in the center of a patch of grease wood in the extreme southwestern corner of the project. Here the determination showed an average of 1.24 per cent of soluble material in the first 6 feet, but this represents an extreme condition, which extends over only a limited area. With proper care in the application of water the alkali can be gotten rid of. Its presence is generally indicated by a scattering growth of grease wood amongst the sagebrush.

This soil occupies level, generally smooth land, and is adapted to the cultivation of potatoes and other vegetables, small fruits, alfalfa, oats, and wheat. It is not so perfectly drained as the type of soil next to be described and will probably require less water to mature a crop. Care will have to be exercised lest overirrigation, especially where there are slight depressions, cause water to accumulate in puddles.

The remaining type of the three main classes of soil is distinctly different from the two already described. In areas where it is typically developed it is composed of a rather heavy, brown loam, about 3 feet in depth. This is generally underlain by fine, sandy loam, a foot or two thick, under which lie beds of sand and fine gravel. In some localities the depth of soil is greater and its texture heavier, more nearly approaching the character of a clay loam or true clay. On the other hand, the surface foot may be a sandy loam, the heavier material underlying.

The main body of soil of this type is found in the northwestern part of the tract, and a narrow strip extends southward from the main body along the extreme western border of the bench clear to the river at Starrs Ferry. Smaller isolated patches are found along the northern border of the tract, where it occupies depressed areas in which water occasionally accumulates to form small shallow lakes. The soil as a whole occupies areas that are slightly depressed below the general level of the bench, and the surface drainage of these areas is cut off from the river by higher land to the south. The land covered by this soil is generally level and smooth; on the whole it has a more uniform surface than that covered by the other types, although there are two or three well-defined depressions, and occasionally a ridge of sand. The depressions are sometimes filled with water to a depth of 2 or 3 feet in seasons of plentiful precipitation, but the empounded waters evaporate during the dry summer months.

Tests made at a few places showed the presence of small quantities of alkali, though as a rule hardly a trace was found. The soil is of such character, however, that if alkali were present it might be brought to the surface by irrigation, and it is possible that a few small alkali patches may develop under irrigation, but no serious trouble from accumulation of harmful amounts of these salts need be feared. Gypsum was found at a number of places, and this salt acts as a corrective for the carbonates, or black alkali, the most troublesome of the alkali salts. These heavier soils should prove to be very fertile. They are of a texture most favorable to wheat growing. Alfalfa, red clover, and timothy are also well suited to this class of land, and sugar beets will undoubtedly do well.

In addition to these three main types, there are narrow strips of recent alluvium on the lowest river terrace. The soil is dark brown, or black, sticky clay loam, 1 or 2 feet deep, resting upon drab clay loam. At a depth of about 4 feet the soil becomes more sandy, and at 6 to 8 feet below the surface black quicksand is generally found.

Soil of this type is of comparatively limited extent. The low terrace upon which it is found lies 8 or 10 feet above mean river level, and in seasons of exceptionally high water it is overflowed, but it is not likely that inundation will ever occur after the dam has been completed and irrigation begun. This alluvial strip is very narrow, varying in width from 3 or 4 rods to one-fourth of a mile. The level surface is here and there furrowed by shallow draws 2 or 3 feet deep, running parallel to the stream channel.

All of these soils generally contain alkali. The soluble salts occur in the first 3 feet and often appear on the surface as a white incrustation. The more sandy subsoils are comparatively free from alkali and an average of the first 6 feet, as determined by several tests made in localities where the salts were most in evidence, showed from one-half to 1 per cent of carbonates (black alkali). Bicarbonates are also present, being the usual form. Quantitative determinations showed in one case 0.03 per cent of carbonates and 0.20 per cent of hydrogen carbonate; in another case 0.13 per cent of carbonates and 0.35 per cent hydrogen carbonate. In the latter form the salt is much less harmful to vegetation than in the former.

On account of the heavy texture of the surface soil, alkali may cause some injury to crops. But with a porous subsoil, which will give good underdrainage, reclamation of the alkali patches should be practicable. At any rate, the total area of the soils in which harmful quantities of the salts are present is so small that the problem is in no sense a serious one.

The principal vegetation upon the alluvial strip is grease wood and sagebrush. In many places the surface is free from vegetation and the cost of clearing this land will be considerably less than that of clearing soil of the other types.

ALKALI CONTENT.

The soils under the Minindoka project are as a whole remarkably free from excessive quantities of alkaline salts. Indeed, it would be hard to find, in the arid region, a district of equal area where so little of these harmful salts is present. Field tests were made by the use of the electrolytic bridge in all parts of the area. The soil was examined to a depth of 6 feet, and where the heavy subsoil extended to greater depths, 9-foot borings were made. Each successive foot was tested, to obtain a fair average and to determine the depth of the stratum where the greatest concentration existed.

These field tests showed, over more than three-fourths of the total area of the project, a content of less than 0.2 per cent of soluble salt, calculated upon the basis of the dry weight of the soil, while areas of soils containing more than 0.5 per cent were exceedingly limited. The amount of alkali that cultivated crops can withstand depends upon the kind of salts, the texture of the soil, and the variety of crops grown. The soluble carbonates or "black alkali" are most harmful; sodium chloride, or common salt, is less harmful, but is more deleterious than the sulphates. Plants can withstand more alkali on heavy soils than on sandy loams. Light soils seldom, however, contain excessive amounts of alkali, and where they do contain large amounts they can usually be easily freed from them by irrigation.

The larger part of the soils of this tract is a light sandy loam, and even where the surface is heavy a porous, sandy subsoil affords excellent underdrainage. The small amounts of harmful salts that are present can be washed out and drained away in the subsoil, if reasonable care in the application of water is practiced. The water of Snake River carries a very small amount of dissolved salt (about 30 parts per 100,000), and accumulation from this source need not be feared.

The kinds of salt in the soil are shown in the following table, which gives the result of laboratory analyses of samples taken at various localities throughout the project, and fairly represents the character of the alkali in the Minindoka area.

Analyses of soils in lands under the Minidoka project.

[Per cent in air-dried soil.]

Laboratory number.	Field number.	Solids soluble in water.	CO_3.	HCO_3.	Cl.	SO_4.	Ca.	Mg.	N (as NO_3).	Na and K.	Description.
330	9	0.66	0.001	0.02	0.28	0.03	0.007	0.005	0	0.18	Sec. 14, T. 10, R. 22. Fine sandy loam; 0 to 9 feet. Region of scattering greasewood. Not on river flat.
331	8	....	....	....	....	....	....	....	....	....	Sec. 16, T. 9, R. 23. Loam; 0 to 6 feet. White powder in subsoil, probably gypsum. Heavy loam from lake bed region.
333	1	.61	.11	.06	.04	.13	.004	.002	0	.19	Sec. 30, T. 10, R. 24. Heavy black loam taken in alkali patch; 1 to 2 feet; contains black alkali. Should show extreme of black alkali for this area.
334	2	.35	.08	.06	.03	.07	.003	.002	0	.12	Subsoil of No. 333. Sticky; sandy loam; 2 to 4 feet; river flat.
335	3	.2–	.03	.05	.005	....	....	....	....	....	Subsoil of No. 334. Light; fine sandy loam; 4 to 6 feet.
336	4	.26	.004	.02	.11	.05	.003	.002	0	.09	Sandy loam; 6 inches to 1 foot; silt loam; 1 to 5 feet; underlain at 5 feet by sand. Taken where white ashy subsoil is typically developed.
337	5	.2–	.00	.03	.004	....	....	....	....	....	SE. cor. sec. 26, T. 9, R. 23. Medium sandy loam; 0 to 2 feet.
338	6	.29	.004	.04	.07	....	....	....	....	....	Subsoil of No. 337. Silty loam; 2 to 4 feet.
339	7	.42	.02	.05	.12	.11	.003	.003	0	.14	Subsoil of No. 338. Silty loam; 4 to 6 feet.
340	10	.2–	.00	.006	.002	....	....	....	....	....	Sec. 5, T. 10, R. 24. Clean sand from dug well 20 feet below surface.
341	11	.2–	.00	.03	.002	....	....	....	....	....	Sec. 5, T. 10, R. 23. Yellow silt from well 26 feet below surface.
342	12	.2–	.00	.03	.002	....	....	....	....	....	Sec. 5, T. 10, R. 24. Blue clay from well 40 feet below surface. This and Nos. 340 and 341 are typical of the three principal substrata.
343	13	.2–	.00	.03	.06	....	....	....	....	....	Sec. 25, T. 9, R. 22. Heavy loam from old lake bed district; 0 to 6 feet.
344	14	.3	.00	.03	.06	....	....	....	....	....	Sec. 9, T. 9, R. 23. Heavy loam from lake bed region; 0 to 6 feet.
345	15	.70	.00	.02	.12	.32	.06	.01	0	.18	Sec. 5, T. 10, R. 24. Fine sandy and silt loam; 0 to 3 feet. Underlain by alkali free sand.
346	16	.43	.004	.03	.15	.11	.004	.004	0	.13	SW. cor. sec. 23, T. 10, R. 23. Silty and fine sandy loam; 0 to 6 feet. Underlain by clean sand.
381	17	.26	.02	.05	.04	.08	.006	.002	0.00001	.08	Sec. 9, T. 9, R. 25. Heavy loam from river flat.

The soluble matter appears to be largely sulphates, with small amounts of sodium carbonate and in a few cases, sodium chloride. The amount of carbonates present is not sufficient to be detrimental except in a few places, but where there is a small amount irrigation without proper attention to drainage is likely to increase rather than diminish this amount.

SOILS SOUTH OF SNAKE RIVER.

A reconnaissance was made upon the south side of Snake River to determine, in a general way, the character of the soils lying under the proposed pumping system. At some future time a more detailed examination may be made and a complete report prepared upon the conditions of soil and alkali.

The land lying under the pumping system differs in several important points from that on the north side of the river. It is comparatively level, the surface sloping gradually toward the river with sufficient grade for the flow of lateral canals. This general slope to the north makes it unnecessary to provide artificial means of drainage on a large scale. Two stream channels, Goose Creek and Marsh Creek, traverse the area, and several smaller draws occur, affording natural drainage ways for any excess waters that might accumulate.

The soils themselves also differ somewhat from those found under the gravity system. In some localities—as, for example, along the river flats—they are of the same character as those found on the north side, but over the major portion of area they are heavier than the soils previously described. The prevailing type is a coherent, rather fine, sandy loam soil 1 foot deep, underlain by loam or silt loam, which reaches to a depth of 2 or 3 feet. At about 30 inches sand and gravel are generally encountered, and at this point it is not uncommon to find a thin calcareous hardpan. Soil borings indicated that this hardpan is not continuous over very extensive areas, but seems rather to occur in broken patches. It was found at depths varying from 1½ to 4 feet, the average being about 2½ feet from the surface.

Another type of soil, which is found chiefly to the west of Goose Creek, is of a more uniform texture and is free from hardpan. It is composed of a light-brown, silty or very fine, sandy loam, with usually a stratum, 1 foot or 2 feet thick, of heavy loam at a depth of 5 or 6 feet from the surface. This heavy stratum carries a moderate amount of alkali (about 0.5 of 1 per cent), but the surface 3 feet of the soil are free from alkali.

Besides these two main classes of soil there is found in narrow strips along the river and Goose Creek a heavier dark-colored loam, in places very sticky and black. This is generally free from alkali, except in a very narrow zone immediately bordering the river banks.

On the whole, less indication of alkali was seen on the south side of the river than on the north side. Several tests were made where a scattering growth of greasewood indicated its presence, and these showed an average of from 0.2 to 0.4 per cent in the first 6 feet. But areas where these comparatively small amounts were found are exceedingly limited, and with the good, natural drainage afforded by the slope of the land and porous layers of sand and gravel in the subsoil it is thought that there will be little danger of alkali accumulating in harmful quantities.

When irrigation is begun hardpan may cause some trouble to the farmer in some localities, but on the whole the conditions of soil under the pumping system are very favorable to agriculture and are adapted to producing large yields from a wide variety of crops.

WATER SUPPLY AND FLOW OF SNAKE RIVER.

The increased use of water for irrigation in the upper Snake River Valley is already having a very marked effect on the discharge of Snake River in the vicinity of Blackfoot and below. At this point the river was entirely dry during the season of 1905 for a distance of about 10 miles. On August 10 a careful measurement was made at a point about 9 miles above Blackfoot by Mr. E. C. La Rue, engineer aid in charge of stream measurements in Idaho, assisted by Mr. Charles Spearman, representing the State engineer of Idaho, and Mr. Walter W. McLaughlin, acting on behalf of the American Falls Canal and Power Company. The point selected was just above the point of diversion of the American Falls Canal. The river on that date was discharging 186 second-feet, but was rising at the time of measurement as a result of the closing down of headgates in the upper valley, which had been ordered a day or two before by the district court. Mr. La Rue estimated that on August 9 about 50 second-feet were flowing at this point. The river at American Falls, a point about 40 miles below Blackfoot, discharged at this time about 2,000 second-feet, and at Montgomery's Ferry, 50 miles lower down, the discharge was 1,987 second-feet.

About 2,000 second-feet will ultimately be required for the irrigation of the Minidoka tract and 3,400 second-feet for the irrigation of the Twin Falls tract, the point of diversion for which is 35 miles below the Minidoka dam. According to recent plans made in connection with the Twin Falls project this diversion may ultimately be increased to 5,500 second-feet, it being proposed to reclaim an additional tract on the north side of Snake River. There would then be required 7,500 second-feet for the reclamation of the lands under these two projects, a total of about 500,000 acres. The mean discharge of Snake River for about forty days during the months of August and September from 1900 to 1905, inclusive, with the exception of 1904, has varied from 2,100 to 2,400 second-feet, or enough for the complete irrigation of about 30 per cent of the land depending upon this source of supply.

The upper Snake River Valley, which extends from American Falls to the upper valleys on the headwaters of the principal tributaries, contains an irrigable area of 790,000 acres, of which about 291,000 acres are now irrigated, as shown by surveys made by the State engineer of Idaho in 1904. The natural discharge of this river has been completely diverted in the irrigation of this area during August of every year from 1900 to 1905, inclusive, excepting 1904.

It should be evident from the foregoing figures that a large amount of storage will soon be needed in this valley. In fact more than 70 per cent of the irrigable area of the Snake River Valley will ultimately obtain water for irrigation during the latter part of the season from storage reservoirs. Fortunately excellent facilities exist for the development of storage works which will be capable of so regulating the flow of this stream that practically every acre of irrigable land tributary to it can be furnished a full water supply during the latter part of every irrigating season.

The most feasible storage sites are on the South Fork of Snake River, and consist of natural lakes. The most practicable of these sites is Jackson Lake, which is situated just east of the Idaho-Wyoming State line, a short distance south of the Yellowstone National Park. The water level of this lake can easily be raised 25 feet, when it will provide a storage capacity of 555,000 acre-feet.

Surveys have been made by the Reclamation Service of other storage sites on this stream, which include Lewis, Shoshone, Emma Matilda, Two Ocean, and Jenny lakes; also a site on the Blackfoot River. These natural storage basins have a combined capacity of about 1,000,000 acre-feet, and can be developed at a cost which will probably not exceed 50 cents per acre-foot.[a]

Several communities in the upper Snake River Valley are already deeply interested in the subject of storage and are now negotiating with the Reclamation Service with a view to participating in the benefits that will result from the construction of storage works at Jackson Lake. It is evident from the results of measurements referred to that a pressing need for this storage will soon exist, and some arrangements, if possible, should be made to the end of providing for other lands besides those under the Minidoka project. This should be entirely feasible, inasmuch as it would add very little, if anything, to the cost of regulating works which will soon have to be erected at the outlet of Jackson Lake.

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[a] For description of storage reservoirs on the South Fork of Snake River see First Annual Rept. Reclamation Service, pp. 186-195.

JACKSON LAKE RESERVOIR SITE.[a]

LOCATION OF DAM.

The only suitable location for a dam is on the South Fork of Snake River about 4,000 feet below the outlet of the lake. At this point the elevation of the water surface in the river is 6,728, or 6 feet below the water surface of the lake. At the proposed dam site the bluffs draw in well toward the river on either side and a dam with a top elevation of 6,769 feet (10 feet above the water surface in the reservoir) would be about 4,300 feet long, while at any point above this the length of the dam would be increased from 50 to 100 per cent, with no appreciable difference in height. Below this proposed site the bluffs gradually spread out and a dam at any point below would be much longer and somewhat higher, as the country falls rapidly below that point. At the site selected advantage can be taken of a rocky point on the south side of the river extending to within about 200 feet of the edge of the stream.

TYPE OF STRUCTURE.

If a suitable rock foundation can be found at a reasonable depth it will perhaps be found most economical to construct the regulating works in the present river bed. A spillway can be easily provided over the rocky ridge on the south side of the stream. The elevation of this ridge is such that the expense of constructing a suitable spillway would be comparatively small.

In case no suitable foundation can be found in the river bed at a reasonable depth it would be perfectly feasible to construct both the regulating works and the spillway in the rocky ridge and use a rock fill in the present river channel. On the north side it will only be necessary to construct an earthen embankment from the river channel to the bluff. Suitable material for such an embankment can be easily obtained.

The elevation of the present bed of the stream is about 6,718 feet. If the water surface be raised to 6,759 feet it is evident that the big item of expense in connection with the dam at this point is the construction of the controlling works, which will consist mainly of cement or masonry and iron work, and which should be designed to discharge 10,000 second-feet of water. Another feature to be considered in designing a structure for this point is the fact that the ice on Jackson Lake during the winter season has been known to be 8 feet thick.

POSSIBILITY OF LOWERING PRESENT WATER SURFACE IN LAKE.

The elevation of the water surface in the lake at the present time is 6,734 feet. The elevation of the water surface at the dam site is 6,728 feet. By excavating the river channel for about 3,000 feet from 1 to 8 feet it will be possible to lower the water surface in the lake to an elevation of about 6,728 feet. The material to be excavated is mostly fine gravel, with more or less loose bowlders and a small percentage of solid rock. As a large additional storage capacity can be obtained in this manner that would otherwise be unavailable without affecting the dimensions of the dam the scheme may be found to possess some merit.

POWER POSSIBILITIES AT MINIDOKA DAM.

The plan to extend the irrigated area under the Twin Falls system will greatly benefit the Minidoka project, since the increased supply of water that will have to be provided for the Twin Falls land can be utilized for power purposes as it flows over the Minidoka dam. The possibilities of irrigation by pumping under this project have been based upon the use of the 2,000 second-feet, the present minimum discharge of the river at these points. When, however, this discharge is increased to 5,500 second-feet, all of which can be utilized for power purposes if desired, the pumping possibilities are more than doubled. The plans as contemplated for irrigation by pumping can easily be extended to embrace a much larger area of land and it is not unlikely that as much as 170,000 acres of land can ultimately be reclaimed under this project. In addition to the irrigation possibilities in connection with the increased flow of the river is the development of power for other industrial purposes, a possibility which should not be overlooked in considering the future of this section. The power possibilities at American Falls will be increased in a similar degree.

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[a] From report by Charles B. Smith, engineer.

PAYETTE-BOISE PROJECT.

The general investigations of this project that were concluded during the field season of 1904 seemed to point to its entire feasibility and to define clearly its limits. It was found that no serious engineering difficulties would have to be overcome and that the estimated cost would fall within reasonable limits.

The project contains four natural subdivisions: (1) The Payette division, comprising the lands of the Payette Valley and the area in the Boise Valley that can be irrigated by the waters of the Payette River; (2) the North Side Boise division, comprising the lands lying on the north side of the Boise River that will be irrigated by means of a canal diverting from that stream; (3) the South Side Boise division, comprising the lands on the south side of the Boise Valley that are to receive water from the Boise River; and (4) the Succor Creek division, consisting of the lands on the south side of Snake River near the Idaho-Oregon State line in the vicinity of Succor Creek, a portion of which could be irrigated by pumping from Snake River, the power to be furnished at the dam to be constructed at the head of the canal on the Payette River, and a portion to receive water from Succor Creek, which stream will be regulated by storage reservoirs.

PAYETTE DIVISION.

LAND COVERED.

The Payette division embraces the following tracts of land: Land on the Payette slope under the proposed main canal and extension, 18,000 acres, all of which is desert; land on the Boise slope below the Boise extension of the Payette canal and above the present Sebree canal, 23,000 acres, which is also desert; land under the Sebree canal and its extension, 19,000 acres, 11,000 of which is desert and 8,000 under cultivation; land under the Riverside canal, on the south side of the Boise River and its extension, 12,000 acres, 8,000 of which are desert and 4,000 under cultivation; a total of 72,000 acres, 60,000 of which are desert and 12,000 under cultivation.

It would also be feasible to attach the areas below the Sebree and Riverside canals to the South Side Boise division, furnishing a supply of late water from the Deer Flat reservoir, the early supply to be furnished by Boise River through the existing canals as is done at present. It may be advisable to adopt this plan temporarily at least, or until the Payette division of the project is completed. Should this be done there would then only be 41,000 acres of desert land depending solely upon the Payette division of the works for their reclamation.

PROPOSED WORKS.

It is proposed to construct a diverting dam on Payette River at a point known as Black Rock Canyon, about 6 miles above the town of Emmett. This dam would be designed to raise the water surface 70 feet above present low water. The dam proper would have a length on top of 500 feet, a bottom length of 140 feet, and a spillway 400 feet long.

It is proposed to construct a canal diverting above this dam on the south side of the Payette River, to follow the foothills for a distance of 26 miles, to a point on the divide between the Boise and Payette valleys. The canal would be divided at this point, one branch being carried into Boise Valley and the other continued along the south edge of the Payette Valley, irrigating about 18,000 acres of land situated above the existing system of canals in that valley. The branch canal which would be carried into the Boise Valley would irrigate 23,000 acres of land situated above the Sebree canal and would also deliver water for use during the latter part of the irrigating season to the Sebree and Riverside canals to be distributed by them to the lands they now serve. This main canal would have a capacity at the head of 600 second-feet, and at the point near the divide 450 second-feet would be diverted into the Boise Valley, the remainder passing down the branch on the Payette slope.

NORTH SIDE BOISE DIVISION.

The lands to be irrigated by this canal are situated on the north side of the Boise Valley, a portion of the area being under the Farmers' Union canal and the remainder under a line which would be an extension of that canal, the plan being to enlarge and extend the Farmers' Union canal for the reclamation of these lands. This division of the project would contain a total area of 33,000 acres, 25,000 acres of which are desert, the remaining 8,000 now being irrigated by the Farmers' Union canal.

This canal, which is about 17 miles long, diverts water from the Boise River at a point about 3 miles below Boise. It would be enlarged to a capacity of 550 second-feet and extended to have a length of 27 miles. No engineering difficulties would be encountered in the construction of this canal. The regulating works at the river would be very simple and inexpensive, consisting of a dam to raise the water about 4 feet. No rock would be encountered in the excavation of the canal.

SOUTH SIDE BOISE DIVISION.

IRRIGABLE LANDS.

The lands embraced in the South Side Boise division are all bench lands and contain a total area of 272,000 acres, 109,000 of which are irrigated or are provided with canals of sufficient capacity for their irrigation. In this estimated area is included the areas under the Sebree and Riverside canals.

The lands in this division are distributed as follows:

Lands under South Side Boise division of Payette-Boise project.

Canal.	Irrigated.	Desert.	Total.
	Acres.	*Acres.*	*Acres.*
New York	[a] 18,000	94,400	112,400
Ridenbaugh	25,000	55,000	80,000
Settlers	11,000	1,600	12,600
Pioneer	[b] 36,000	....	36,000
Riverside	[c] 10,000	2,000	12,000
Sebree	9,000	10,000	19,000

[a] Based upon present capacity of 14,000 inches at four-fifths inch per acre.
[b] Capacity of existing works capable of delivering water to 36,000 acres.
[c] Major portion of works have capacity capable of irrigating 10,000 acres.

The actual amount under cultivation in this division is only 72,000 acres, but as provision has already been made in the construction of some of these works for the diversion of more water than can at present be supplied, and as these works will all be available for use as a part of a system proposed, it has been necessary to classify some of the areas as irrigated in adjusting the values of existing works, so there would actually be 163,000 acres of land in this division without irrigation works of any kind and 200,000 acres without a sufficient water supply.

PROPOSED CANAL SYSTEM FOR SOUTH SIDE BOISE DIVISION.

It is proposed to utilize the New York canal by enlarging and extending it and making it the main canal on the south side of the Boise Valley. This canal and its extension would cover 112,400 acres, comprising the area situated above the Ridenbaugh canal south of Meridian and Nampa and the area above the Pioneer district and Riverside canal, on the divide between Boise and Snake rivers. In addition to this area this canal would supply practically all the desert lands lying under the Ridenbaugh canal—about 55,000 acres—making a total area of about 160,000 acres of desert lands which would be irrigated from this source. In addition to this there would be about 18,000 acres of land for which canal capacity and water right already exist.

This canal will divert water from the Boise River at a point about 8 miles above Boise, near the mouth of the canyon. Its course from this point will run southwestward to Indian Creek, a distance of 26 miles. The major portion of its discharge will be dropped into Indian Creek, down which it will flow for a distance of about 9 miles to a point about 4 miles southeast of Nampa. At this point it will be diverted in a canal and conducted to the proposed Deer Flat reservoir, a distance of about 14 miles.

It is proposed to give this canal a capacity of 1,500 second-feet from the point of diversion to the reservoir. At some future time the section between the river and Indian Creek will be enlarged to a capacity of 2,700 second-feet, sufficient to irrigate the lands lying southwest of Indian Creek.

DAM IN BOISE RIVER.

A diverting dam will be constructed in Boise River at the head of this canal. This dam will be of masonry, with a timber apron. It will be 250 feet long on the crest and will raise the water 31 feet above average low water. Considerable power could be developed at this point, which could be used for pumping water onto higher lands or for municipal and other industrial purposes.

DEER FLAT RESERVOIR.

One of the most important features of the work in this division is the Deer Flat reservoir. This reservoir is situated about 4 miles west of Nampa. It contains an area of 9,250 acres and has a total capacity of 186,000 acre-feet. Two dams will be constructed—one, the upper dam, having a maximum height of 70 feet and a total length of 4,100 feet; the other, the lower dam, having a maximum height of 45 feet and a length of 7,200 feet. These dams will be made of earth and gravel, the formation and contour of the ground at the sites being very favorable for dams of that type. The reservoir will have a maximum depth of 60 feet at the upper dam and 33 feet at the lower. Water will be diverted 30 feet below the maximum height, which will give a net capacity for distribution of 170,000 acre-feet.

About 107,000 acres of bench lands are tributary to this reservoir, but water could be delivered to fully 20,000 acres on the first bottom of the river in addition to this area.

Careful investigations have been made of the formation at the site of the dams and over the entire area covered by the reservoir. In making these tests an ordinary churn drill was used. Owing to the peculiar formation in this locality, this method was somewhat slow and unsatisfactory and 20 test pits from 12 to 38 feet deep in the vicinity of the proposed dam sites were dug by hand in order that the nature of the formation might be more thoroughly examined. The formation as shown by the wells examined and the test holes drilled indicates nothing unfavorable near the surface. There are no gravel beds of any sort exposed in the basin and at no point examined is there less than 4 feet of soil and hardpan above any such formation.

In doing the testing in the vicinity of the proposed dams it was thought advisable to have pits dug, as a more thorough examination could be made of the material encountered.

In some of these pits it was necessary to use curbing, especially in the holes on the hilltop, where sand and gravel were encountered. No curbing was used in the holes in the flat or on the axis of either dam. Good compact material was found in all of these holes.

DISTRIBUTING SYSTEM.

By constructing a distributing canal from the upper dam water can be delivered from this reservoir over about four-fifths of the Pioneer irrigation district. A main distributary from this point could be constructed to irrigate about 4,500 acres lying south of Nampa, above the boundary of the district. This canal would cross the Oregon Short Line Railway about 1 mile above Nampa and intersect the Phillis canal at a point about 2 miles north of that place and would have to be constructed through a portion of the town site, over which right of way would likely be very expensive.

Another route investigated for this distributary provides for a drop about 2 miles east of the point of diversion, which would avoid the town site at the drop. A small canal could be continued on the upper grade plane to cover the lands in the immediate vicinity of Nampa, distributing the water through the system of ditches now used on the town site. This is the plan by which four-fifths of the Pioneer district could be irrigated, and the one which seems most feasible.

Another main distributary would be constructed from the lower dam of the reservoir. This canal would follow the ridge between Boise and Snake rivers, delivering water to about 40,000 acres of land, all of which is desert. The construction of this canal would be very simple, the ground being practically level throughout and the formation being earth.

SUCCOR CREEK DIVISION.

This division contains an area of 25,700 acres, all of which is in a desert condition. It is proposed to construct three storage reservoirs on Succor Creek, which would have a combined capacity of 31,500 acre-feet, which, together with surplus flow of Succor Creek, would be available for the irrigation of 10,000 acres. In addition to this, 15,700 acres bordering Snake River could be reclaimed by pumping from that stream.

WATER SUPPLY AND STORAGE.

Boise River is sufficient for the irrigation of all the lands tributary to it, but the fluctuations in its flow are so great that storage is necessary to increase the area under cultivation, which comprises less than one-third of the lands below the level of existing canals and their extensions.

It was hoped, when these investigations were begun, that suitable sites for reservoirs could be found on the headwaters of Boise River, but after very careful examinations had been made and numerous sites had been surveyed it was decided that only two basins would be available for the purpose, and these can be developed only at considerable cost. Fortunately, however, it was discovered that the Deer Flat basin could be utilized to good advantage. It will irrigate all the lands for which storage can be developed.

The storage conditions were found to be more favorable on Payette River, an excellent site existing at Payette Lake, which can be utilized at small cost.

The reservoirs referred to on Boise and Payette rivers are described in the Third Annual Report of the Reclamation Service, pages 238 to 240.

It is estimated that from 65,000 to 70,000 acre-feet can be stored in the two reservoirs on Boise River. This water will be used on the lands situated under the high line canals of the valley, lands above the distributing system from the Deer Flat reservoir. This supply will not be sufficient for the entire area so situated, but it is expected that the amount thus furnished can be supplemented by water which now belongs to the lower Boise lands, but which, after the construction and use of the Deer Flat reservoir, can be supplied to the upper canals, so that practically all of the land situated under these higher canals can obtain water during the entire irrigating season.

It is the plan to give the canals which would be constructed a large capacity—1 second-foot for each 60 acres of land—with a view to furnishing the abundant supply of flood water which will be available to the later part of June of every year. This will insure the successful irrigation of all kinds of crops up to that time. Not much irrigation will be required for grain after the end of June, so that it is believed there will be enough water from the natural flow of the river for the irrigation of grain crops and, during most years, for two cuttings of hay, and that by adopting an economical system for the distribution of the late water—the considerable area which will require only early irrigation being then laid aside—there will be provided, by the means proposed, a sufficient supply for the late irrigation of the remaining area.

The storage system developed on the Payette River will be necessary for regulating the flow of that stream during the later part of August and the month of September during years of low water. There will be many seasons, however, when these works will not be necessary unless it should be decided at some future time to utilize the power facilities that will be available at the dam on Payette River. Should it be decided to develop much power at this point, the flow of the river could be regulated to almost any degree, so that a large amount of power could be developed without interfering in any way with the irrigation rights lower down on the stream.

APPROVAL OF THE PROJECT.

A report containing plans and estimates was presented to a project board consisting of the governor and State engineer of Idaho and engineers of the Reclamation Service. A recommendation was made by this board that the project as a whole be approved and that steps be taken for the construction of a portion of the undertaking that would form a complete project in itself. The portion recommended for immediate construction was a part of the South Side Boise division of the project, it being recommended that the New York canal be acquired, to be enlarged and extended in the manner already described, and a reservoir constructed on Deer Flat. In making these recommendations, however, the board proposed that the main canal should be constructed to full capacity, namely, 2,700 second-feet.

In March, 1905, favorable recommendations having been made to the Secretary of the Interior, the project was approved and $1,300,000 was set aside for immediate use in the construction of the necessary works. Detailed surveys of the works proposed in this division were at once begun, and careful surveys were made of the New York canal, the Deer Flat reservoir, and of all main distributaries leading from the reservoir. These surveys were completed and estimates made during October, 1905.

USE OF THE NEW YORK CANAL AND ITS EXTENSION.

Negotiations were also conducted and concluded by the Reclamation Service for the transfer of the New York canal and its extension to the United States, the contract for the transfer of this property having been duly authorized by the stockholders of the companies interested.

PURCHASE OF THE RIDENBAUGH CANAL SYSTEM.

One of the conditions upon which the approval of the project was based was the purchase by the landowners of existing canal systems operated on a rental basis. The only system coming under this head is the Ridenbaugh canal. The Nampa-Meridian irrigation district was organized in 1903 for the sole purpose of acquiring this property. In December, 1904, a bond election was held for the purpose of authorizing the issuance of bonds sufficient to purchase the system and enlarging it so that it would be capable of irrigating about 80,000 acres of land, 25,000 of which were at that time under cultivation. The bonding proposition, however, was defeated. In July, 1905, another bond election was called, the plan being to issue bonds sufficient to pay the purchase price of the canal, $285,000, this amount to be paid by the lands now being irrigated by the system. It was proposed that the desert lands of the district should receive their water from works which would be constructed by the Government. This plan was laid before the voters of the district and after a thorough discussion was approved at an election held August 26, the votes standing 10 to 1 in favor of the plan proposed.

No provision exists in the irrigation district law of Idaho for changing the boundaries of an irrigation district after they are once established, so it became necessary to devise a plan by which this canal system could be acquired by the district and by which at the same time the owners of desert lands might secure water rights from the Government works and the Government project might proceed without depending upon the district organization. The last provision was very desirable, owing to the fact that the irrigation district law and the reclamation act appear to be somewhat at variance in a few essential features.

The plan to charge the purchase price of the Ridenbaugh canal to the lands that have been using the water therefrom met the approval of all concerned, and the arrangement that the owners of desert lands within the district should take water from the Government works was also desired, and the successful conclusion of negotiations for the transfer of the New York canal to the Government to be used as a main canal will enable these arrangements to be carried out without delay or conflict in any way. The owners of desert land within the boundaries of the district really assume none of the obligations of this organization, and any delay that may occur in concluding the sale of bonds and taking over the Ridenbaugh canal will not involve the United States in any way whatever, since the water users who will pay for this system will be interested only in procuring a supply of water that can not be directly furnished until storage works on the headwaters of the Boise River are constructed.

PURCHASE OF RIGHT OF WAY.

Another condition upon which the approval of the project was based was the negotiation for the purchase of the necessary right of way on Deer Flat by the Payette-Boise Water Users' Association. These negotiations involved the purchase by the United States of 6,675 acres of land on Deer Flat, 5,869 being desert and 806 being under cultivation, some of it well improved. The negotiations were begun in May, 1905. A careful examination of these lands was made by members of the Water Users' Association, and an effort was made to place a value on them which would do justice to all parties interested. Although many of the owners raised objections to the value placed on their holdings, many contracts for purchase have been entered into, and it is thought that all differences can be satisfactorily adjusted and the necessary right of way acquired without resorting to condemnation proceedings.

DUBOIS PROJECT.

The preliminary investigations made during the field season of 1903 showed that there were from 300,000 to 400,000 acres of desert land in the western portion of Fremont County of fine quality and well situated for irrigation. (See Pl. XVI.) These investigations also indicated that it would be entirely feasible to construct canals for the reclamation of a portion of this tract. During the latter part of the field season of 1903 a reconnaissance survey was begun on the headwaters of the North Fork of Snake River and its tributaries with a view to ascertaining the existence of reservoir sites, for it was found that the feasibility of the project finally depended upon the practicability of storing about 700,000 acre-feet of water of these streams. These preliminary investigations were intrusted to Mr. James G. Camp, engineer, and were completed during the latter part of the field season of 1904—too late, however, to permit the results to be included in the Third Annual Reclamation Report.

RESERVOIR SURVEYS.

GENERAL STATEMENT.

Twenty reservoir sites were surveyed by Mr. Camp, most of them good, but not all located just where they would be most needed. The combined capacity of these reservoirs is 1,840,000 acre-feet, fully twice as much as will likely be required in connection with this project.

The following is a list of these basins, showing their location, proposed depth of water, and capacities:

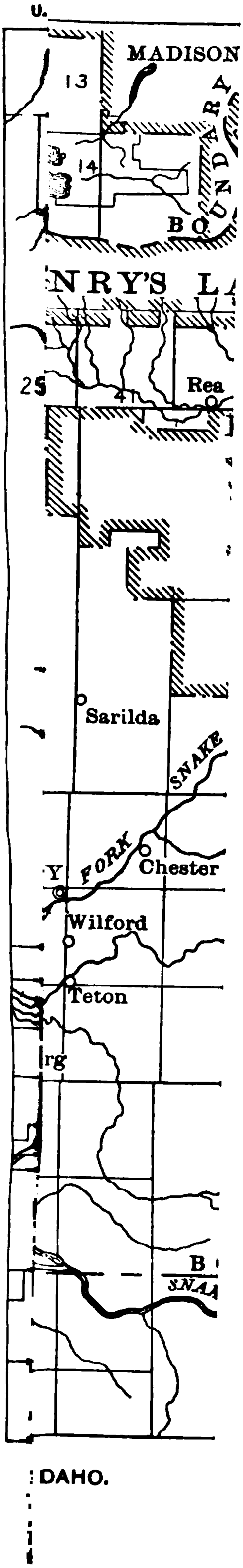
Table showing location, depth, and capacity of Dubois reservoir system.

Location.	Name of reservoir.	Proposed depth of water.	Capacity
		Feet.	*Acre-feet.*
North Fork Snake River	Henry Lake	20.0	112,000.0
Do	Flat Rock	50.0	194,000.0
Do	Island Park	70.0	294,700.0
Robinson Fork of Warm River	Little Porcupine	90.0	8,470.0
Fall River	Fall River Meadows	50.0	234,000.0
Do	Mountain Ash	25.0	1,280.0
Do	Upper Ford	30.0	1,330.0
Do	Grassy Lakes	50.0	6,950.0
Do	The Forks	25.0	7,275.0
Do	Beula Meadows	12.5	2,169.0
Do	Beula-Hering Lake	25.0	10,354.0
South Fork Snake River	Shoshone Lake	15.0	289,000.0
Do	Lewis Lake	30.0	22,440.0
Do	Aster Creek	50.0	23,715.0
Tributaries of Fall River	Canyon Creek	70.0	16,940.0
Do	Crooked Lake	25.0	1,060.0
Do	Loon Lake	25.0	1,280.0
Do	Upper Boon Creek	30.0	7,250.0
Do	Lower Boon Creek	55.0	5,544.0
Do	Squirrel Creek	25.0	6,685.0
Teton River	Teton Creek	100.0	422,200.0

Estimates of water supply based on the recorded flow of the low years of 1902–3 show that there would be available for storage on the North Fork above Teton River 900,000 acre-feet; from Fall River, 400,000 acre-feet; from Teton River, 400,000 acre-feet, and from Lewis River at the outlet of Lewis Lake, 110,000 acre-feet; a total of 1,810,000 acre-feet.

Of the 900,000 acre-feet on the North Fork, Henry Fork furnishes approximately 523,000. Of the three reservoirs on this stream Henry Lake will have 112,000 acre-feet, Flat Rock 194,000 acre-feet, and Island Park, with 90-foot dam, 501,000 acre-feet, a total of 807,000 acre-feet. As this is 284,400 in excess of the supply, it would probably be advisable to use a lower dam at Island Park, which is most costly of the three. With a 75-foot instead of a 90-foot dam Island Park would have a capacity of 294,700 acre-feet. These three would have a capacity of 601,000 acre-feet, with a supply of 523,000 acre-feet in extreme low years, and almost a certainty of any three years' flow keeping them full for three years.

Of the available flow of Fall River in 1902–3, 206,200 acre-feet came from Belcher River and could have been used in the Fall River Meadows site. As this site with a 50-foot dam has a capacity of 195,000 acre-feet, and with a 55-foot dam 234,000 acre-feet, it



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would seem advisable to use the latter, especially as no lower sites are available, and in normal years this reservoir would be very apt to be filled. This also brings surplus water from Mountain Ash reservoir by ditch into this reservoir.

The primary reason for these investigations was the need of 700,000 acre-feet storage on the North Fork. This can be obtained cheapest in the following four sites, if diversion is necessary above where Teton water would be available in order to use the water on the Dubois project:

Most feasible sites for storage, Dubois project.

Name	Capacity in acre-feet.
Henry Lake	112,300
Flat Rock	194,000
Island Park	294,700
Fall River Meadows	195,000
Total	796,000

If it were desired to store as large a per cent of the available water of North Fork and Teton rivers as is practicable within reasonable limit of cost, then the following should be added to the above:

Additional sites available for storage, Dubois project.

Name.	Capacity in acre-feet.
Fall River Meadows (increased 5 feet in depth)	39,000
Mountain Ash	62,800
Teton (100-foot water line)	422,200
Total	524,000
Total of preceding table	796,000
Total	1,320,000

In this table the Teton reservoir water line was cut down from the 110-foot line to the 100 foot, as the amount of water available for storage at that point will probably not exceed 400,000 acre-feet.

Following are descriptions of seven available reservoir sites which it may be feasible to use in connection with the Dubois project.

FLAT ROCK RESERVOIR.

This site covers an area of wild meadow, some of it taken up as ranches, with very little improvement. The eastern side and the slopes to the southwest are heavily timbered with black (or jack) pines and scattered firs. Over half of the river flows from the big springs on the east side, and this would be the main source of supply, although in the spring there is a large run-off from the high mountains to the northeast.

The dam site is a good one, being where a rocky point on one side is opposite an earth point on the other. The river bed is gravel and small bowlders. Half a mile above the site a ledge of soft sandstone crops out in the river bed, and would probably be found at no great depth at the dam site. On both sides is higher ground, from which material could be hauled for construction. The soil is sandy with broken rock and bowlders.

Both sides are heavily timbered. On the west side the abutment for the dam is apparently an outcrop of a ledge of sandstone covered with soil. This point is from 100 to 200 feet wide on top and could be cut to water level for a wasteway. The outlet could be a tunnel through this point. The main body of water being around a point, not much protection will be necessary against wave action. A long gap on the east side greatly increases the cost of construction. A dam containing 216,700 cubic yards of earth is necessary to prevent water flowing into Buffalo River drainage. If accurate gaging shows that there is not 194,000 acre-feet available at this point after filling Henry Lake, the cost would be greatly reduced by lowering these dams. An old road traverses this basin, but as a shorter new one leaves the river below the dam site and crosses only a small portion of the shore line the change will not cost much

Capacity of Flat Rock reservoir.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
5	51.4	128	128
10	247.7	748	876
15	1,182.3	3,575	4,451
20	1,976.6	7,897	12,384
25	3,114.0	12,727	25,111
30	3,495.3	16,523	41,634
35	5,990.7	23,715	65,349
40	7,747.7	34,371	99,720
45	9,757.0	43,761	143,481
50	11,467.6	50,561	194,006

ISLAND PARK RESERVOIR.

This is one of the largest basins, and if there was sufficient water could have a capacity of 501,000 acre-feet. As low years would leave only 216,000 acre-feet for this site after filling those above, it was reduced from a 90-foot to a 75-foot water level, which at the lower dam gives 294,700 acre-feet.

Two dam sites were surveyed here, one at the beginning of the canyon and one about a mile lower down the river. Both were estimated for 70-foot and 85-foot water lines, respectively, but under existing conditions the lower dam is the cheaper and would give the greater storage capacity. Both dam sites are in lava-rock canyons and would be rock fill in the canyon, with earth wings on the bluffs on either side. At either place is abundant rock in shattered cliffs. No quarrying would be necessary. The blocks are from 2 to 20 feet square and, with a cable, most of the rock could be run in by gravity. The estimates were made on rock fill, faced with earth puddle, 25 feet on top, 1½ to 1 lower slope, 3 to 1 upper slope. The outlet could be either a curved tunnel in the canyon side or a masonry tunnel through the dam. The wasteway could be at either end of the dam or through a gap on the east shore line into Warm River. As there are never any cloudbursts in this country nor extreme high water, there is but little need of a wasteway. It would be desirable to hold all the flow, and it could be regulated by the outlet gates. About 6,000 acres of farm land in this basin add 25 per cent to the cost. The northeast portion of the basin is meadow and prairie land, the balance very heavily timbered with a dense growth of jack pines that would make an accurate location survey expensive unless the right of way were first burned off, which would be the cheapest way to clear it.

Capacity of Island Park reservoir with upper dam 75 feet in height.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
5	101.8	254	254
10	285.8	967	1,221
15	585.5	2,178	3,399
20	803.6	3,473	6,872
25	1,167.3	4,677	11,549
30	1,712.7	7,200	18,749
35	2,771.1	11,209	29,958
40	3,383.1	15,146	45,104
45	5,051.4	21,086	66,190
50	6,645.0	29,241	95,431
55	8,028.0	36,682	132,113
60	8,962.6	42,477	174,590
65	9,916.0	47,196	221,786
70	11,168.2	52,711	274,497
75	12,238.3	58,516	333,013
80	13,387.8	64,066	397,079
85	13,995.3	68,457	465,536

HENRY LAKE RESERVOIR.

This site is a natural lake situated near the head of Henry Fork. The dam site is about 2 miles below the outlet. The dam would be only 25 feet high and its construction presents no difficulties. The material is a sandy loam with gravel and bowlders. Protection against wave action would be necessary.

Capacity of Henry Lake reservoir site.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
0	3,722	0	0
5	5,013	21,837	21,837
10	5,840	27,132	48,969
15	6,311	30,377	79,346
20	6,905	33,040	112,386

FALL RIVER MEADOWS RESERVOIR.

This site has a fine basin, a succession of mountain meadows forming a very flat bottom. The slopes are thickly timbered with jack pines. These slopes bear numerous springs and are traversed by many small streams from the surrounding mountains joining Bechler River, which flows through the basin. In one of the meadows is a small group of hot springs, but these are of no importance from a scenic point of view. A private Yellowstone Park road passes through the basin, but this could pass over the dam, or will probably be abandoned for a Government road west of the basin. The dam will be 3.3 miles long and 55 feet high at the river.

The bed of the river at the point where it crosses the dam site is formed of solid lava rock. The wings of the dam will follow a string of irregular hills that extend from the river back to the mountain on the east and to a high bench on the west. Much of this will need only from 10 to 15 foot embankment. On the west side is an excellent place for a wasteway; a

10-foot wall would drop the water on to a flat ledge of rock, from which it would descend to a rocky canyon, carrying it to the river, 1½ miles below the dam.

The outlet could be a masonry tunnel on the rock bed of the river. Plenty of good material—a sandy loam mixed with small, broken rock—can be found near the dam site. The dam line is mostly in thick black pine timber.

Here, as at the North Fork sites, wave action would have to be guarded against; probably the cheapest and most permanent protection would be willows. These grow readily and would soon form a dense growth that would prevent any damage from waves. As a temporary protection until they had become started, rafts of pine logs could be floated and anchored on the upper side of the dam. Long before these would have rotted the willows would stand any waves probable in this section.

Capacity of Fall River Meadows reservoir site.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
0	0	0	0
5	115	288	288
10	2,770	7,220	7,510
15	3,790	16,400	23,900
20	4,290	20,200	44,100
25	5,020	23,300	67,400
30	5,540	26,400	93,800
35	6,620	30,400	124,000
40	7,180	34,500	158,000
45	7,520	36,700	195,408
50	....	....	234,000

MOUNTAIN ASH RESERVOIR.

This site has a very irregular basin with a number of lakes, meadows, and willow flats. Fall River, Mountain Ash Creek, Proposition Creek, and a number of small creeks traverse the basin. The basin is formed by an irregular ridge which extends from the Pitchstone Plateau on the north to the mountains on the south. In places this rises several hundred feet above water line, but it will be necessary to dam four gaps. The main one is where the river makes a sharp bend to the north and passes through the ridge, which seems to split, the ends on opposite sides lapping each other. Here the basalt foundation of the ridge is hidden by a surface of sandy soil mixed with broken rock. Big bowlders in the stream and rapids below would indicate that solid rock exists at no great depth below the bed of the stream. There being no rock within a mile of the dam site, estimates were made for an earth embankment with puddle center. The outlet would be of masonry, under the dam. The wasteway could be made at either of the three side gaps. The gap on the north side is near the present Yellowstone National Park road. This would be an earth embankment and presents no difficulties, plenty of material being convenient. A ditch was surveyed from this gap as a feeder to Fall River Meadows reservoir. A ditch 1.8 miles long would reach it with 10 feet difference in elevation. It would have easy slopes, but would have to cross one rocky canyon, where a flume would be necessary. A rocky gap on the east side leads to Canyon Creek reservoir. An earth embankment would be sufficient except at the south end, where a wasteway could easily be made by building a rock wall on top of a rocky ridge and allowing the waste to fall on a rock slope. From this gap a feeder ditch line was run southeastward to Crooked Lake and thence to Boone Creek reservoir; but as the lake has sufficient local drainage, and a light cut at a gap at the head of Loon Lake would be far cheaper as a feeder, this will not be used.

The fourth gap is on a rocky ridge near the south end of dam, and is small. If a lower water line had been used these gaps need not have been considered, but the available supply being greater than the capacity the water line was put up to the limit.

Capacity of Mountain Ash reservoir site.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
5	0.0	0	0
10	18.7	47	47
15	79.4	247	294
20	327.1	1,016	1,310
25	383.1	1,776	3,086
30	534.6	2,294	5,380
35	794.4	3,348	8,728
40	1,238.3	5,062	13,790
45	1,271.0	6,273	20,063
50	1,612.1	7,207	27,270
55	2,113.0	9,313	36,583
60	2,710.3	12,058	48,641
65	2,944.0	14,166	62,807

LEWIS-SHOSHONE LAKES RESERVOIR.

Shoshone Lake was surveyed for a reservoir in 1902 by J. T. Burke, who planned a 20-foot dam at the outlet. Surveys made in 1904 demonstrated that there was a difference of only 10 feet in elevation between the two lakes, and it was decided to combine the two in one reservoir by a dam at the outlet of Lewis Lake. The outlet of Shoshone into Lewis Lake is a sluggish stream with but little fall except just below the upper lake.

Two dam sites were surveyed. The upper site was at a wide gap where there were hot springs, and was not considered desirable. Half a mile below the lake a good site was found in solid rock—68 feet across the bottom, 338 feet across the top, and 45 feet high. If it were not 100 miles distant from a railroad point at which cement might be delivered, a masonry dam might be best here, but an earth embankment with concrete core should be perfectly safe. Plenty of sand could be found on the lake shore half a mile above and earth on either bank of the river. Rock points jutting out on both sides would make good anchorage. At the west end of the dam is a rocky knoll with a gap between it and the main hill. This could be cut down about 10 feet and used as a wasteway, a draw carrying the water back to the river 1,200 feet below the dam, but the dam would better be 10 feet too high than to lose water even one year out of five. The Park road, which would have to be moved, is not permanent, but temporary, and a road equally good could be made higher up the mountain side. The design in surveying this site was to use the water on North Fork drainage by diverting from Lewis River and carrying by ditch around the mountain side to some point on the divide east of Beula Creek, the most easterly branch of Fall River.

Three lines were run. The upper one, starting just below the dam, at an elevation of 7,700 feet, was 11.98 miles long to the crest of the Beula divide. The second line was started below Lewis Falls at an elevation of 7,653 feet. It was 11.99 miles long. The third line contemplated dropping the second line at the end of the eighth mile into the natural channel of Crawfish Creek, then diverting as low as possible from that creek with a ditch line 5.2 miles long, and entering Hering Gap at the water level of Beula-Hering reservoir.

The first or high line encountered a slide-rock bluff at the end of the first mile and one-half that would necessitate three-fourths mile of flume. Between east and west forks of Spirea Creek it encountered considerable rock, and the last mile was largely on a slide-rock hillside full of big springs. The second line at the end of the first mile entered the rocky rim of the Lewis Canyon and was largely in rock for 3.3 miles, after which it encountered no special difficulties. The lowest line could avoid rock entirely.

Contours were located by vertical angles above and below these lines, and when platted up the intervening ones were interpolated.

As a solution of the problem of the two bluffs at the head of these lines a diversion dam was planned at the head of the Lewis Canyon to divert at an elevation of 7 685 feet. On the map a line was projected with this initial elevation and a grade of 0.4 foot in 1,000. At east fork of Spirea Creek it was dropped to 7,665 feet to avoid rock beyond, and at Station 317+96 it was dropped to the low line, which it followed to the Beula divide. Estimates were made on this; also on an alternative line dropping at Station 420+11 of the low line into Crawfish Creek and thence using the third line.

The ditch was to carry 1,500 second-feet on a grade of 0.4 foot in 1,000. Rock cross section 36 feet on top, 24 feet on bottom, 12 feet deep; banks, one-half to 1 slope. Earth cross section, 39 feet on bottom, 75 feet on top, 12 feet deep; banks, 1½ to 1 slope.

Capacity of Lewis and Shoshone lakes reservoir site.

Contour.	Lewis Lake.		Shoshone Lake.		Total capacity.
	Area.	Capacity of section.	Area.	Capacity of section.	
Feet.	*Acres.*	*Acre-feet.*	*Acres.*	*Acre-feet.*	*Acre-feet.*
15	28.0	....	....	....	....
20	3,219.3	162	....	....	162
25	3,659.0	17,195	....	....	17,357
30	4,051.0	19,275	....	....	36,632
35	4,205.6	20,647	8,005	38,692	95,971
40	4,257.0	21,156	8,456	41,152	158,279
45	4,302.0	21,397	8,704	42,900	222,576
50	4,673.0	22,438	8,900	44,010	289,024

TETON RESERVOIR.

This is the largest of all the sites and presents no difficulties in construction. The dam site is at the lower end of the basin, where a lava flow formerly dammed the river. Through this it has broken a channel, leaving very abrupt bluffs of shattered lava on each side. The site is especially adapted to a rock-fill dam, for plenty of loose rocks of all sizes lie close at hand at elevations that will permit them by means of a cable to be placed in the dam by gravity. The bed of the stream is of loose rock, but solid rock on both sides would indicate that rock should be found at no great depth. A puddle face could be put in very cheaply, as, by extending an irrigation ditch 3 miles along the ridge that forms the north side of the reservoir, water could be brought to the hill at the north end of the dam and the sandy loam sluiced into the dam. The outlet tunnel, which would be under the dam, could probably be more cheaply constructed of masonry. The wasteway would be on the north end, where there is a sloping bench of lava. A broad channel could be excavated, and, with a guiding wall, the waste could be dropped into the canyon 500 feet below the dam.

The basin is in part taken up as farms. About one-fourth is willow swamps, one-fourth dry hills, and the balance is only partly in cultivation.

Capacity of Teton reservoir site.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
5	9.2	20	20
10	23.4	81	101
15	42.0	163	264
20	102.3	361	625
25	215.0	793	1,418
30	528.0	1,858	3,276
35	1,042.0	3,925	7,201
40	1,640.2	6,755	13,956
45	2,439.2	10,199	24,156
50	3,350.5	14,474	38,630
55	3,990.7	18,353	56,983
60	4,640.2	21,577	78,560
65	5,243.0	24,708	103,268
70	5,911.0	27,885	131,153
75	7,032.7	32,359	163,512
80	7,943.9	37,441	200,953
85	9,369.1	43,295	244,248
90	10,710.3	50,198	294,446
95	12,598.1	58,271	352,717
100	15,191.6	69,474	422,191
105	16,948.6	80,476	502,667
110	18,668.2	89,042	591,708

CONCLUSIONS.

The conclusions are that if but 700,000 acre-feet are needed, it can be obtained cheapest by the use of four sites, namely, Henry Lake, Flat Rock, Island Park (75-foot dam), and Fall River Meadows (with 50-foot dam), these giving 796,000 acre-feet; and that if the greatest capacity within reasonable limits of cost is desired six sites should be used, namely, Henry Lake, Flat Rock, Island Park, Fall River Meadows (with 50-foot dam), Mountain Ash, and Teton (with 100-foot water line), which give a total capacity of 1,320,000 acre-feet.

FUTURE OF THE PROJECT.

Owing to the fact that storage facilities will have to be provided on practically every important branch of North Fork of Snake River in order to furnish an adequate supply of water for the reclamation of the lands under this project, consideration must necessarily be given to existing water rights. The conclusions reached are based upon an estimate of 150,000 acres of irrigable lands in the Snake River Valley proper tributary to the North Fork. An irrigation survey made by the State engineer of Idaho in 1904 shows that there are 220,000 acres of irrigable land in this vicinity. Of this area 95,500 acres are now irrigated, and practically the entire flow of most of the branches of this stream is already diverted during the later part of the irrigating season. In order, then, to insure the greatest benefits to this community, it will be necessary to provide storage for the major portion of the irrigable lands in the valley proper before diverting a large amount of water to another drainage.

For the foregoing reasons the reclamation of the lands under the Dubois project does not offer a tempting field for the use of private capital. The present irrigators in Snake

River Valley would not agree to have a reservoir system constructed for them by private capital. Although the cost per acre-foot of developing such a system will not be great, yet the aggregate amount of capital required would be very large. This, added to the large amount required for the construction of a canal system in connection with the reclamation of the Dubois land, would swell the total cost per acre beyond a reasonable amount from the standpoint of a private investor, and when the allowance for profits is added to this amount the cost to the settler would undoubtedly be prohibitive.

All of the land under the project belongs to the United States, except sections 16 and 36, which belong to the State of Idaho. These lands are vacant and there seems to be no inclination on the part of the public to risk homestead filings at the present time.

GENERAL RECONNAISSANCE.

General reconnaissance surveys were continued during 1905, an examination of the headwaters of Salmon River being made. This examination completes the survey of the arid portion of Idaho by the Reclamation Service, which has also made estimates of the irrigation possibilities in each drainage system.

The results of examinations made on Big and Little Wood rivers, Big and Little Lost rivers, Birch, Medicine Lodge, and Camas creeks were negative, for on these streams either an adequate water supply is not available or suitable dam sites do not exist. Every basin that seemed to present any natural advantages for storage was surveyed, but only a few of them were worth considering at all.[a]

BIRCH CREEK RESERVOIR.

The facilities for storage on Birch Creek are typical of those on most of these streams.

Two sites were surveyed on this creek. The upper one is in Blaine County in the northeast part of T. 10 N., R. 29 E., which has not been subdivided. At this dam site there are solid lava abutments on both sides which are nearly vertical. The length of the dam on the bottom would be 500 feet and on the top 715 feet. Here the creek seems to be flowing on bed rock. Above the dam site the slopes of the basin are gravel and not very steep, varying from 1 to 1 to 10 to 1. There are a great many springs in the basin, which vary in discharge from a small part of a second-foot to 5 second-feet. The small streams in the upper part of Birch Creek sink and seem to be forced to the surface again in the basin covered by the reservoir site. At the dam site the discharge of Birch Creek on August 26, 1904, was 110 second-feet. As this stream is fed mostly by springs above this point the flow remains almost constant during the entire year. Mr. E. Tyrell, who has lived at this place for several years and has noted the condition of the creek, states that it rises for only a few days during the spring season and then not to a very great height above the normal flow. The condition of the banks of the stream seems to bear out Mr. Tyrell's statement. The capacity of the reservoir with a dam 80 feet high to hold 75 feet of water would be 18,166 acre-feet. The capacity of the reservoir is shown in the following table:

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[a] For general description of basins surveyed see Third Annual Report, Reclamation Service, pp. 264-265.

Capacity of upper Birch Creek reservoir.

Contour.	Area.	Capacity of section	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
5	2.7	6.7	7
10	9.1	29.5	36
15	19.1	70.5	107
20	33.0	130.2	237
25	50.2	220.2	457
30	85.2	588.5	796
35	126.0	528.0	1,324
40	202.0	820.0	2,144
45	291.0	1,232.0	2,376
50	356.0	1,617.0	4,993
55	405.0	1,920.0	6,895
60	480.0	2,262.0	9,017
65	559.0	2,597.0	11,704
70	642.0	3,002.0	14,706
75	742.0	3,460.0	18,166
80	838.0	3,950.0	22,116

The lower reservoir site is also on Birch Creek, in Blaine County, in the southeastern part of T. 10 N., R. 25 E., and is unsurveyed. The dam site is about 2¼ miles below the dam site of the upper reservoir. There are solid lava abutments on both sides, the length of the dam on the bottom being 350 feet, and on the top 700 feet. The creek at this point seems to be flowing on bed rock. Above the dam site the slopes of the basin on the east side are steep, with broken lava cropping out of the gravel; on the west side the banks have a slope of about 5 to 1. There are some springs in this basin, but not so many as in the upper one.

The discharge of Birch Creek at this dam site on August 27, 1904, was 115 second-feet and, as at the upper site, the flow is approximately constant throughout the year. The capacity of the reservoir with a dam 80 feet high, 75 feet of water, would be 17,571 acre-feet.

The following table shows the capacity of this reservoir:

Capacity of lower Birch Creek reservoir.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
5	0.0	0	0
10	.8	2	2
15	5.9	21	23
20	15.7	54	77
25	63.0	197	274
30	95.0	396	670
35	161.0	640	1,310
40	212.0	832	2,142
45	262.0	1,185	3,327
50	315.0	1,442	4,769
55	389.0	1,710	6,429
60	470.0	2,147	8,676
65	542.0	2,530	11,206
70	632.0	2,935	14,141
75	740.0	3,430	17,571
80	810.0	3,875	21,446

There is a large body of very fertile land on Reno Flat, about 25 miles southeast of the reservoirs, which is well situated for irrigation, and to which the waters from these reservoirs could be conducted. Measurements made by the water master of this district show that nearly one-third of the water in Birch Creek sinks between the lower dam site and the point where it should be diverted in order to reach the lands. In order to prevent this loss it would be necessary to construct a canal throughout the entire distance. It is estimated that the loss in such a canal would not be very great, this conclusion being based upon measurements made in August, 1904, of the Reno ditch, which is diverted from this creek and runs to these lands.

Although the lands on which it would be desirable to conduct this water would be very fertile it is extremely doubtful whether they could stand the cost of storage, to say nothing of the cost of constructing a canal. The major portion of the normal flow of this stream has been allotted by the court, so only a portion of the run-off would be available for storage. It would probably be necessary to provide at least 3 feet of water in depth for each acre of land to be reclaimed, to which amount should be added the probable losses by seepage and evaporation from the reservoir and canal. This would probably amount to at least 2 feet per acre, making 5 feet per acre which should be stored in the reservoir.

DIVERSION OF SNAKE RIVER INTO THE SALT LAKE BASIN.

Considerable speculation has been indulged in during the past two years in relation to the possibilities of conducting the water of Snake River into the Bear River drainage, to be used in the upper portion of Cache Valley, Utah. With a view to determining the feasibility of this plan Mr. J. B. Bond, assistant engineer, in September, 1904, examined the country between Blackfoot and Port Neuf rivers, this being the lowest place in the divide between the two drainage systems.

While Port Neuf River is a tributary of the Snake there would be no difficulty whatever in continuing a canal line from its valley into either Cache Valley or Bear River Valley. In fact, this is the only route which it would be practicable to follow, even if the plan referred to were entirely feasible in other respects.

A casual examination of the country between Blackfoot River and Snake River indicates the impracticability of diverting water from the latter stream and carrying it as far as the divide referred to, so the plan narrows itself to the diversion of water from one tributary of Snake River, namely, the Blackfoot.

The point of diversion from Blackfoot River would have to be below the proposed Blackfoot River reservoir site, otherwise the supply of water available for use under the plan proposed would not be worth considering. This reservoir is about 40 miles southeast of the town of Blackfoot, the dam site being in sec. 12, T. 5 S., R. 40 E., B. M. Two routes for a canal between the divide referred to and points on the river below this dam site were investigated.

Line No. 1 would divert from the river about 17 miles below the reservoir site and about 2 miles from the point on the divide between Blackfoot and Port Neuf rivers, known as Dead Man's Pass. A diverting dam would be required in the Blackfoot River 70 feet high. This dam would be 275 feet long on the bottom and 350 feet on top, the site being in solid lava, with walls rising about 90 feet above the river. The estimated cost was based upon the construction of a rock-fill dam with gravel back filling. The gravel could be obtained from a hill about 700 feet from the dam and could be sluiced into place very cheaply with water taken out of Grave Creek about 1½ miles from the dam.

Line No. 2 would divert from the river at a point about 9.3 miles above the pass. A diverting dam 150 feet in length and 15 feet in height would be required. The first 3.3 miles would be along the side of a rocky canyon and would have to be flumed; the remaining 6 miles would be in earth and gravel.

No examination was made of the land which this water would serve, but it is estimated that from 25,000 to 30,000 acres on Port Neuf River could be thus reclaimed. There is only one other plan by which these lands can ever be reclaimed, and even by this only a part of the area can be reached; that is, by the construction of a canal to divert water from Bear River at a point near Soda Springs. But the natural flow of Bear River is already utilized in the reclamation of lands in the Cache Valley. It would therefore appear to be more economical to utilize the waters of Blackfoot River on the higher lands in the Port Neuf River Valley, provided the plan for the diversion of water from this source should ultimately be found to be feasible, and use the water furnished by Bear River for the reclamation of lower lands, as in Cache Valley.

The investigations referred to were not carried on in sufficient detail to determine the feasibility of the smaller scheme under consideration, but enough was learned to justify the statement that the much-talked-of plan to divert the waters of Snake River into Salt Lake Valley is impracticable from every standpoint.

CEDED LANDS OF THE FORT HALL INDIAN RESERVATION.

Closely related to any plan for the utilization of the waters of the Blackfoot River is the reclamation of the irrigable lands of the Fort Hall Indian Reservation. Blackfoot River can be utilized to better advantage in the reclamation of these lands than of any other. An excellent reservoir site furnishes facilities for controlling the flow of the stream, the water supply being just about sufficient to supplement the flood discharge of Snake River, which will always be available for early irrigation. The lands of the reservation lie directly adjacent to Blackfoot River, and only a short distance from the reservoir site, while they are situated more than 200 miles below the storage reservoirs which will be constructed at the head of the South Fork of the Snake River. For these reasons alone it would seem that the policy of the Government in reserving certain public lands on the Blackfoot River for reservoir purposes is a wise one, especially when it is considered that the probable users of the water which may some day be stored at that point are wards of the nation.

Efforts having been made from time to time by citizens of Pocatello and vicinity to have the lands embraced in this reservoir site restored to public entry or to have the site turned over to private parties to be developed for the purpose of irrigating lands in the vicinity of Pocatello, an investigation was made by the Reclamation Service with a view to ascertaining the feasibility of reclaiming a portion at least of the ceded lands of the reservation by extending the irrigation system that has already been constructed by the United States for the reclamation of Indian lands. This investigation was made in September, 1904, by Mr. J. B. Bond, assistant engineer, a survey having been made of an extension of the reservation canal from Ross Fork Creek through the ceded lands near Pocatello.

These lands are situated in the southern part of T. 5 S., R. 34 E., and T. 6 S., R. 34 E., and lie in a very compact body. The total area that can be irrigated is 12,400 acres; of this about 1,000 acres lying along the Port Neuf River are rough and rocky and can not be cultivated. The remainder of the land is a sandy loam, and if it were watered would be susceptible of a very high state of cultivation. The land is rolling, but not too rough for irrigation. A strip of low ground runs the entire length of the tract near the eastern edge and between the main body of land and the canal as it would be extended from Ross Fork Creek. This low strip of ground gives rise to the same problem that is encountered in irrigating the major portion of these lands by means of the extension of the reservation canal—a problem that would present itself in the consideration of any other plan of irrigation, no matter how high up on the Blackfoot River the point of diversion might be located, or from what direction the lands might be approached with a canal. To get across this low ground either a siphon or a long heavy fill would have to be used in any case.

The end of the reservation canal is at Ross Fork Creek in the NW. ¼ sec. 6, T. 5 S., R. 35 E. The line of the proposed extension began at this point and was run out on a grade of 1 foot to 5,000 feet in a southeastern direction. This line skirted the foothills along the east edge of Snake River Valley and terminated at Pocatello. The construction of this main canal would not be difficult. The ground slopes gently toward the west. Neither rock nor sand was encountered at any point along the line. The lateral slope is very light; hence an economical canal section with a minimum amount of fill could be used.

At a point on this line about 9 miles below the lower end of the present reservation canal a small ridge connects the high ground to be irrigated with the foothills on the east. Here either an inverted siphon would have to be built or a long heavy fill constructed to convey the water across to the lands to be irrigated. The distance across is 3,200 feet, allowing a vertical drop of 17 feet. If a fill were constructed, a short siphon would have to be put in to carry the water under the Oregon Short Line Railroad, which crosses the divide at this point. With a fill or siphon there would still be 2,000 acres too high to be covered except by pumping. Electric power for pumping should not be very expensive. The American Falls Power and Light Company now has a transmission line running across the track. As the power for pumping could be used only during the irrigating season, when the load would be the lightest, and as this company now generates more power than it can dispose of, favorable terms could probably be made.

A line was run from the lowest point on the divide across which the proposed siphon or fill would have to be constructed to ascertain the area that could be covered by dropping the water from the main canal at this point. This line would cover a strip of land along the Port Neuf River, varying in width from one-half to 1 mile and embracing 2,500 acres of tillable land.

Four plans for reclaiming the land with the cost per acre in each case are given below. Under each plan the capacity at the rate of 1 cubic foot of water per second was provided in the canals for the irrigation of each 60 acres of land.

Plan No. 1 provides for reclaiming the entire area of 11,400 acres. This would require a canal 9 miles long, with a capacity of 190 second-feet, from Ross Fork Creek to a point where water is taken across the lowland in a siphon; a lateral 3½ miles long, with a capacity of 35 second-feet, from end of main canal to Pocatello; a siphon 3,200 feet long, with a capacity of 155 second-feet, and canals to carry water from the end of the siphon to the land to be irrigated. For pumping a 50-horsepower motor and pumps with a capacity of 35 second-feet would be required.

Plan No. 2 would reclaim the same area as plan No. 1, but instead of a siphon an earth fill would be required with a siphon, 50 feet long, under the Oregon Short Line Railroad track, which crosses the divide at this point.

In plan No. 3 the area to be covered by pumping is left out, leaving an area of 9,400 acres. An earth fill would be constructed instead of siphon, 50 feet of siphon being used under the railroad track. The volume of water required in main canal is 157 second-feet.

In plan No. 4 the area covered by both pumping and siphon or fill are left out. It would then be necessary to build a main canal with a capacity of 75 second-feet. At the point where the proposed siphon or fill was to have been constructed the water is dropped from the main canal to the lowest part of the divide and then carried by a gravity canal around nearly to Port Neuf River.

Under this system a narrow strip along Port Neuf River, a narrow strip between the main canal and the Oregon Short Line Railroad track, and a small body of land adjoining Pocatello on the north would be reclaimed. The total area would be 4,400 acres.

At the time the survey was made the reservation canal was running at about one-half of its maximum capacity. No gaging was made, but it was estimated that 50 second-feet were flowing at the time. This would give the canal a capacity of 100 second-feet. Most of this water is now used by the Indians along Ross Fork Creek. To furnish water for the ceded lands the reservation canal would have to be enlarged so as to carry about 300 second-feet.

Water for this tract would probably have to be supplied by storage during the later part of the irrigating season. This could be provided very cheaply at Blackfoot Marsh, on the Blackfoot River. A 30-foot dam at that point would give a capacity of 195,000 acre-feet. The total cost, including right of way, should not amount to more than 50 cents per acre-foot. The water could be allowed to run down Blackfoot River to be diverted directly by the reservation canal.

RECONNAISSANCE OF THE UPPER SALMON RIVER DRAINAGE BASIN.

CHARACTER.

Upper Salmon River is a typical mountain stream. It has its source in the high mountains of north-central Idaho and flows northward through the central part of Custer and Lemhi counties for a distance of 110 miles. It then turns abruptly to the west and enters a very rough and nearly impassable country. Examination was made of the portion of the basin that lies between the point where the river enters the extremely rough country and the head of the stream. The point where the river enters the rough country is 9 miles north of Salmon City, the county seat of Lemhi County. The bed of the river is very rough. From the mouth of the East Fork to Salmon City, a distance of 75 miles, the stream has a fall of 17 feet to the mile. On the west side of the river the mountains are steep and rugged, and rise to an elevation of from 10,000 to 11,000 feet above sea level. Above 7,500 feet there is a heavy growth of small pine and fir timber. Below this elevation there is very little timber or underbrush. The streams flowing from the mountains are short and steep. While the spring rises are very sudden and the run-off very great, the dense timber and deep canyons hold back enough of the snow to furnish a good water supply during the entire summer.

On the east side of the river the mountains are less steep, but rise to about the same height as those on the west. There is little timber or underbrush to retard the run-off, and the spring floods are sudden and of short duration.

From the head of Salmon River to Challis, the county seat of Custer County, there is no tillable land, save small tracts of alluvial soil at the mouths of the creeks. These tracts contain from 40 to 200 acres each and for the most part are under cultivation, water from the creeks being obtained without much difficulty. Six miles above Challis the river emerges from a canyon and flows through a tillable tract of land containing several thousand acres. This tract is known as Big Round Valley. Eight miles below Challis the river again enters a canyon, through which it flows for over 40 miles. Nine miles above Salmon City the canyon walls again break away from the river and the stream flows for 18 miles through a narrow valley to the mouth of the Lemhi River. In the canyon between Challis and Salmon City small alluvial tracts are found at the mouths of the creeks. These, too, have been settled upon and are being cultivated. Not taking into account these small tracts, the tillable land in Upper Salmon River drainage basin lies in three bodies, namely, Big Round Valley, Pahsimeroi Valley, and Lemhi Valley

BIG ROUND VALLEY.

On the east Big Round Valley merges into Antelope Valley. Between them there is only a low ridge, through which Antelope Creek has cut a channel, and the two valleys are considered as one tract. This land comprises a part of T. 13 and 14 N., R. 19 and 20 E., also some unsurveyed land lying farther east and south. The area of the tillable land is about 35,000 acres. In elevation it ranges from 4,750 feet on Salmon River to 6,300 feet at the upper end of Antelope Valley. The soil is porous and gravelly. Alfalfa and timothy hay do well here. Hardier vegetables and fruit thrive and yield bountifully. The slope of the land toward the drainage channels varies from 1 to 500 to 1 to 20. This steep slope, together with the porous soil, accounts for the large quantity of water required for irrigating the lands. The duty of water here seems to be about 25 acres to the second-foot. Four thousand acres of the cultivated land lie on the west side of the river. The water for this land is obtained from Garden Creek Challis Creek, and Salmon River.

Four thousand acres of tillable land on this side of the river is still without water, Challis and Garden creeks not being capable of furnishing an adequate supply. This is bench land lying at an elevation of about 200 feet above the river. The supply in the river is abundant, but to bring water onto this land by gravity would require a canal 15 miles in length. The first 7 miles would be along canyon walls, where it would be necessary to construct a flume and blast a bed for the flume out of solid rock. This expense would amount to more than the value of the land after its reclamation.

During the winter months and the flood season enough water runs to waste in Challis and Garden creeks to reclaim this tract. It has been represented that good storage reservoirs could be constructed on both Challis and Garden creeks. A careful examination was made of both of these creeks and nothing was found that was feasible, the slope of the country being great and the basins too narrow. A survey was made of the most promising reservoir site. This is at Eddy Basin, on Challis Creek, on unsurveyed land. There is a good dam site here, solid rock abutments rising to a height of 135 feet on each side of the creek. A dam 100 feet in height would be 310 feet long on the bottom and 363 feet on top. But a dam of this height would impound only 4,000 acre-feet. If it were constructed to the height of the abutments, 135 feet, the capacity would only be 9,500 acre-feet. Materials used in construction, except the stone and sand, would have to be hauled in wagons for a distance of 60 miles.

On the east side of the river 3,500 acres of tillable land lie from 50 to 175 feet above the river. A gravity canal from the river to irrigate this land would encounter the same obstacles that are met on the west side. It would be necessary to blast out a bed and flume the water around rock walls for 7 miles, the cost of which would be prohibitive.

Water could be pumped from Salmon River to the tracts on each side of the stream. Just above the Eddy Basin dam site, on Challis Creek, about 8 miles northwest of Challis, is a very good location for a power house. With a ditch constructed in earth 1 mile in length and 500 feet of fluming or wood-stave pipe around a shale hillside a head of 200 feet could be obtained. Six miles above Challis, where the river flows from the canyon, the pumping plants could be installed. On the east side of the river the lift would be about 175 feet; on the west, 200 feet. The transmission line would be 14 miles long.

On June 18 the discharge of Challis Creek at the site for the power house was 80 second-feet, but it was stated locally that the minimum discharge was a little less than half this amount—probably about 30 second-feet—all of which would be available, as this is 2 miles above the point where it would be diverted for irrigation.

Where Antelope Creek has cut through the ridge that divides Antelope Valley from Big Round Valley there is a narrow canyon one-half mile in length. Above this canyon is a basin 2 miles long and one-half mile wide. This was represented to be a good reservoir site, but upon examination it was found to be too steep. A dam here could be constructed to a height of 135 feet. The length on top would be 265 feet; on the bottom, 80 feet. There are solid rock walls on each side. A dam of this height would hold only 13,000 acre-feet. The capacity of this reservoir would decrease very fast with decrease in the height of the dam. Even if the price of constructing the reservoir were not too great, the available water supply is not sufficient for the purpose required. Antelope Creek is fed by springs that rise about 3 miles above the dam site. Mr. Van Camp, who has lived in this section for twenty years, states that the discharge of the creek is practically constant during the entire year, and the condition of the banks seems to bear out his statement. On July 8 the discharge of Antelope Creek was 2.8 second-feet. During four months of the year this water is used for irrigation.

Representations having been made that it would probably be feasible to bring water from East Fork of Salmon River through Stage Station Pass—a pass between Antelope Valley and East Fork—into Antelope Valley, to reclaim the lands of Antelope and Big Round valleys, an investigation was made of the country, but the scheme was found to be impracticable. Stage Station Pass is 6,500 feet above sea level. It is too long to tunnel through, while a canal from East Fork through this pass would be 35 miles in length; 20 miles of this would be along steep rock hillsides, much of it being perpendicular bluffs. Three deep canyons would also be crossed, where inverted siphons a mile in length would be required. After the pass is reached the distributing system would be very expensive. The total area reclaimed would be only 25,000 acres.

PAHSIMEROI RIVER.

The largest tract of tillable land in the Salmon River drainage basin lies along Pahsimeroi River. Pahsimeroi River forms the boundary between Custer and Lemhi counties. It flows northwestward, entering Salmon River 20 miles north of Challis. The valley is 50 miles in length and will average about 5 miles in width. The bottom lands along the river have an area of about 30,000 acres and are for the most part under cultivation. Along each side of the river, next to the foothills, are benches formed by alluvial fans that spread out from the mouths of the canyons. The slope of this bench land toward the river is about 250 feet to the mile, and toward the lower end of the valley about 40 feet to the mile. There are a few ranches on this bench land near the mouths of the canyons, but the greater part of it is unreclaimed. The area of the arid land in the valley is about 100,000 acres. Within a few miles of its head the river begins to sink into the gravel, which is of great depth and very clean and uniform. The wells in the valley have encountered the same sort of material as far down as they have been dug. For about a month during the extreme high stages of water the river flows as an unbroken stream from its head to its mouth. During the remainder of the year the bed is dry for a distance of 20 miles. Half way between the head and the mouth springs begin to appear in the bed of the river, and from this point to its mouth the amount of water increases very fast. Snow-fed streams, many of them of considerable size, are found in every canyon leading toward the river. The water in these canyons, without exception, begins to sink as soon as it reaches the alluvial fans referred to. During high water many of these streams reach the river, but as the flood season passes the water gradually disappears in the sand, and the bed from the mouth of the canyon to the river is left dry.

The canyons on each side of the valley were examined for reservoir sites but nothing feasible was found. A site at the upper end of the valley in Goldburg basin was surveyed. This covers a part of secs. 33, 34, and 35, T. 13 N., R. 23 E. At the dam site there is an impervious layer of soil or stone a short distance beneath the surface. The length of a dam 60 feet in height would be 1,000 feet on top and 980 feet on the bottom, with wings 15 feet in height and 1,400 feet long. One-half mile north of the north abutment of the dam is a gravel hill which seems to be excellent material of which to construct an earth dam. Flowing just above this hill is a ditch carrying 10 second-feet of water. This ditch is at such an elevation that a head of 100 feet could be obtained, and the gravel could be sluiced into place very cheaply. But even with this advantage the reservoir would prove too costly for the land. A dam 60 feet high would form a reservoir having a capacity of about 16,000 acre-feet. Four hundred acres of patented land would be flooded.

The amount of water used per acre in this valley is very great. It is true that in many instances it is applied wastefully to the soil, but the soil is so porous that more water is needed here than in the average irrigated country. On the Curtis ranch, near the head of the valley, 12 second-feet were being used constantly on 200 acres of grain and alfalfa. The crops do not seem to be overwatered and the owner stated that he could not possibly raise a full crop with less. The ranchers in the vicinity gave the amount of land that could be irrigated by one second-foot as being from 15 to 30 acres.

There is considerable water in the river at the lower end of the valley but the benches stand so high that a gravity canal from the river can not reach them, and the topography of the country is such that pumping would not be feasible. The water rights in this valley have not been adjudicated. The early settlers took the choicest pieces of land, and in getting water on to it the ditches were not constructed on any uniform grade. In most places a few furrows were plowed from the mouths of the canyons to the land. These ditches are so steep and shallow that much of the water is lost. Instead of several of the ranchers taking out a ditch together, the most of them have constructed separate ditches, which causes another loss. If the ranchers would unite, take the water out in one ditch built on a uniform grade, each one taking only the amount of water he could use beneficially, new homes could be created with water from nearly every creek in the valley. There are no engineering obstacles to be overcome, but the tracts which would be reclaimed would be scattering and small, and these small and scattering tracts could not be included in one project. There are no storage possibilities in this country, and the area that can be reclaimed is too small to justify Federal aid.

LEMHI RIVER.

Lemhi River rises in the southwestern part of Lemhi County and flows for 80 miles in a northeastern direction, emptying into Salmon River at Salmon City. In the upper end of the valley there is a large basin, lying about 6,000 feet above sea level, in which there are perhaps 50,000 acres of tillable land. About 10,000 acres of this are now being cultivated, leaving 40,000 acres yet to be reclaimed. The conditions here are much the same as on the Pahsimeroi.

There are no sites for storage reservoirs. Several basins were found on creeks near the head of the valley, but they were too steep to be utilized for reservoirs. At the normal flow all of the water is now being used. The soil here, as on the Pahsimeroi, is very porous and a large amount of water is required per acre. About 30 miles below the head the foothills come in close to the river and the valley is only about three-fourths of a mile in width. From this point to the mouth the water keeps increasing, being fed by springs and small streams. All of the tillable land on both sides of the river is being cultivated, as is the tillable land at the mouth of the Lemhi, in Salmon City Valley, receiving a bountiful supply of water from Salmon and Lemhi rivers.

Upper Salmon River drainage basin is at present remote from any railroad and can be reached only by a long and tedious stage journey. Markets are few and far between. There are many promising mining properties in this section, but the lack of transportation has retarded their development. The principal industry is stock raising. Hay for the stock is the principal crop raised on the ranches. The high, open hills afford excellent pasture during the summer months, but the range is stocked to its full capacity. There is hay enough being raised to feed all the stock during the winter months, but there is a demand for very little more. Cultivated land sells from $20 to $30 per acre. On this land two crops of alfalfa of about 2 tons each can be cut during the season. The soil is rich, and vegetables and the hardier fruits thrive, but as there is no market for these the production is not very great. If a railroad ever enters this country and the mines develop there will be a home market for all of the produce that can be raised. The value of land will increase and projects that are not feasible at the present time might then be worthy of investigation. But even then it is thought the only body of sufficient size that would pay to reclaim would be the tract in Big Round Valley, which could be irrigated by pumping.

STREAM GAGING.

During the season of 1905 fourteen gaging stations have been maintained. On May 31 the Gimlet station, on Big Wood River, and the Carey station, on Little Wood River, were discontinued. A new station was established on Big Wood River near Shoshone, Idaho, on June 5, 1905.

The records from the twelve remaining stations furnish data from which the daily discharge of every important stream in southern Idaho can be obtained. These stations are so located that in practically every case the stream-bed cross section remains permanent. In a comparatively short time rating tables for these stations can be constructed that will apply for years to come, at which time the cost of stream gaging in Idaho will have been reduced to a minimum.

In addition to gagings at regular stations many miscellaneous measurements have been made. In August a study was made of the low-water conditions on Snake River between

Blackfoot and Twin Falls. In October a series of measurements was made on Boise River to determine the conditions of flow between Boise and Caldwell, Idaho.

This work has been carried on by E. C. La Rue, engineering aid, in charge of stream gaging in Idaho.

COOPERATION OF THE STATE.

The most cordial cooperation and support has been given to the Reclamation Service by the State administration, the governor and the State engineer having acted as members of a project board in the consideration of plans relating to both the Payette-Boise and Minidoka projects. The State land board has cooperated with the Reclamation Service in matters relating to the laying out and opening of town sites under the Minidoka project, having decided to have a section of land belonging to the State which lies adjacent to one of the tracts reserved for town-site purposes by the United States subdivided for the same purpose.

At the eighth session of the State legislature a law was enacted which provides that State lands situated under irrigation works to be constructed by the United States shall, upon notice being given to the governor of the State that the construction of works has been authorized by the United States, be sold subject to the restrictions of the reclamation act as regards area of farm units, and that no sale of such lands shall be consummated until the proposed purchaser shall have purchased a water right from the United States for the reclamation of such lands. The following is the text of the law referred to:

SECTION 1. There is hereby granted, over all the lands now or hereafter belonging to the State, a right of way for ditches, tunnels, and telephone and transmission lines constructed by authority of the United States. All conveyances of State lands hereafter made shall contain a reservation of such right of way.

SEC. 2. Whenever the United States shall, through its proper officers, authorize the construction of any irrigation works in this State under the provisions of the reclamation act of June 17, 1902, no lands belonging to the State whose irrigation depends upon the construction of such works shall, after such authorization for construction shall have been publicly announced or communicated by such proper officer to the governor of the State, be sold except in conformity with the classification of farm units by the United States, and the title to such lands shall not pass from the State until the applicant therefor shall have fully complied with the provisions of the laws of the United States and the regulations thereunder concerning the acquisition of the right to use water from such works, and shall produce the evidence thereof duly issued.

OPERATIONS IN KANSAS.

By Charles S. Slichter.

GARDEN CITY PROJECT.

LOCATION.

The Garden City project is planned to be constructed on Arkansas River just east of Deerfield station, on the Atchison, Topeka and Santa Fe Railway, 14 miles west of the city of Garden, Kans. The location shown on the map, Pl. XVII, is in the bottom lands of Arkansas River just west of the boundary line between Kearny and Finney counties. The headgates of an irrigation canal, known as the Farmers' ditch, which diverts water from Arkansas River to the uplands north and west of the city of Garden, have been constructed at this point. This canal has a maximum capacity of about 200 second-feet and is used during the irrigation season whenever there is water in Arkansas River, but the unreliability of the perennial flow of the river at this point makes the use of the canal very uncertain.

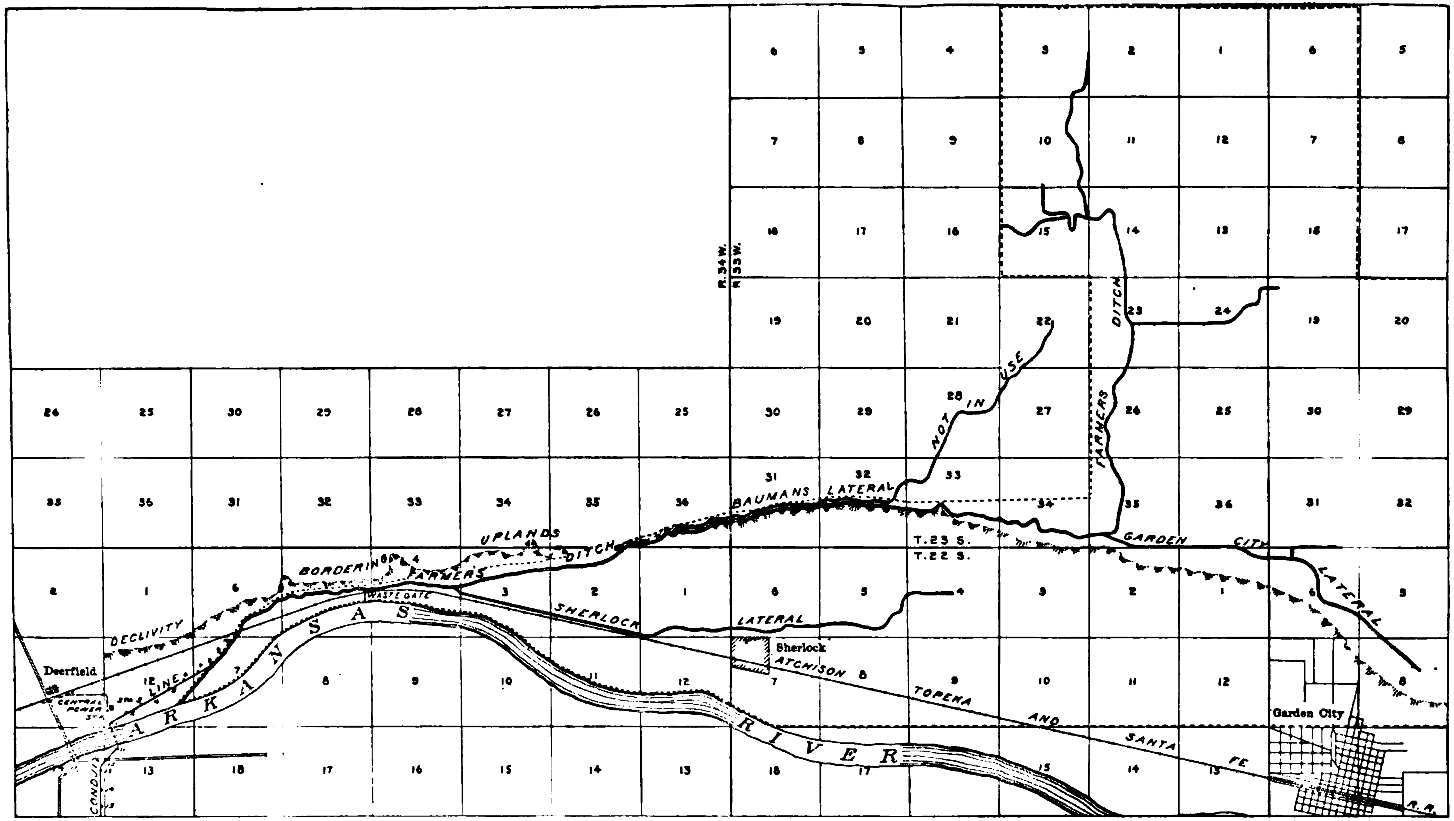
The amount of land at present entitled to water from this canal amounts to 8,600 acres, but the acreage supplied by the canal can be greatly increased, provided a sufficient quantity of water is available.

DESCRIPTION OF PROPOSED PLANT.

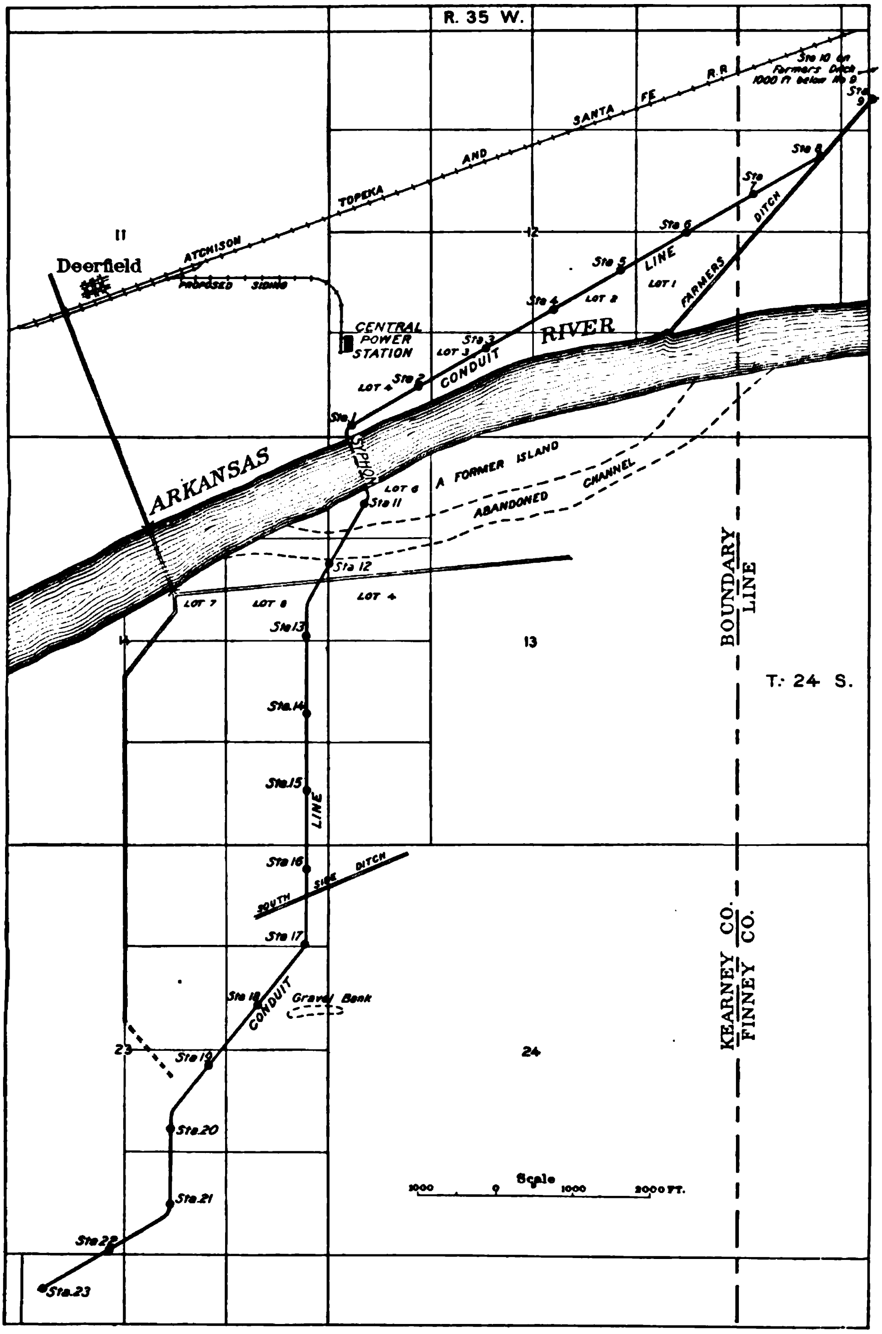
It is proposed to install a pumping plant to recover an average of 100 second-feet of ground water during the irrigation season of five months, to be delivered into the Farmers' ditch about 1 mile northeast of its headgates. The pumping plant will consist of 23 separate pumping stations, each discharging into a concrete lined flume or surface conduit, which ultimately reaches the Farmers' ditch as described. The location of the proposed pumping plants is indicated on the map, Pl. XVIII. In this diagram the separate pumping stations are numbered from 1 to 10 on the north side of the river and from 11 to 23 on the south side of the river. The entire plant is to be driven from a central power station, located about the middle of the line of pumping plants, from which the power will be distributed electrically to the 23 separate pumping stations. The total length of the line covered by the wells and conduits of the various stations amounts to about 23,000 feet, the individual stations being spaced at intervals of 1,000 feet along the main conduit. Ten of these stations are on the north side of the river, but 13 must be built upon the south side of the river, which necessitates a crossing by an inverted siphon.

DESCRIPTION OF INDIVIDUAL PUMPING STATIONS.

Each separate pumping station will consist of a set of ten bored wells, connected by suction pipes to a No. 9 vertical shaft centrifugal pump driven by a 25-horsepower vertical motor. Pl. XIX shows the details of the proposed sets of wells. In the lower left-hand corner of this diagram a sketch is given showing the five well pits, of concrete, each one containing two wells. The central pit contains the pump; the rectangular portion of the pit is housed over with a concrete structure designed to protect the machinery from the dust and weather. The wells shown in the diagram consist of two classes. It is proposed that one, near the central pump house, shall be 300 feet deep. This is designed to be constructed of California stove-pipe casing, or other suitable material, 12 inches in diameter,



GENERAL MAP OF GARDEN CITY PROJECT, KANSAS.



LOCATION OF POWER STATION AND PUMPING PLANTS, GARDEN CITY PROJECT, KANSAS.

extending full size throughout its total depth. All other wells shown in the diagram are to be of 15-inch casing and to extend to a depth of 40 to 60 feet. It is proposed to case the shallow wells with slotted galvanized-iron casing, made of 16-gage galvanized iron, provided with three-sixteenth by 1¼-inch "hit or miss" perforations, punched before the iron is galvanized. The perforations or openings are designed to occupy about 40 per cent of the total area of the well strainers.

The average distance from the surface of the ground to ground water throughout the line of proposed wells is 6½ feet. For a large part of this distance the depth to water is only a few feet, consequently the concrete pump pits will vary from 5 feet to 10 feet in depth. Concrete well pits will be needed only at stations 16 to 23.

The suction pipes leading from the various wells to the centrifugal pump are designed to be made of galvanized spiral-riveted steel pipe, with all-flange connections. The suction pipes to the individual wells are so designed that they may be readily removed for the purpose of cleaning or inspecting the wells.

The wells are constructed in pairs and placed as close together as practicable, so as to increase the specific capacity of the individual wells by a method described below. The end well pits, if thought desirable, can be provided with three wells instead of two. It is proposed to develop a high specific capacity in the wells by running clear water into one well while the twin well, 5 feet distant, is vigorously pumped. Tests of the material in the Arkansas underflow show that such treatment will clear the gravel of fine material, and tend to transform the water-bearing gravels between the two well casings into a very coarse percolating medium.

It is contemplated to perforate the 300-foot well opposite all good water-bearing strata that may be found. The exact depth of bed rock in this locality is not accurately known; at Garden it has been found to be over 300 feet deep.

TOTAL CAPACITY AND SPECIFIC CAPACITY OF THE WELLS.

Careful tests of the pumping plants in the bottom lands of Arkansas River, made during the summers of 1904 and 1905, show that each square foot of well strainer can be relied upon to furnish 0.25 gallon of water per minute, under one-foot head. This subject has already been fully reported upon and discussed in a report by the writer.[a] The table on page — gives the principal data obtained from these tests. In many of the existing wells the strainers or feeders are placed only a few feet apart, and even under these conditions the specific capacity of 0.25 gallon per minute for one foot of head is maintained. Tests of the city well at Garden, Kans., show that no deterioration in its capacity has taken place during five years of daily pumping. In addition to this, investigations made of the actual rate of movement of the underflow in the Arkansas River Valley, as well as the samples of material procured at various depths, show that the deposits in the valley are very uniform in character. Since the specific capacity of 0.25 gallon per minute was exceeded in nearly all the pumping plants tested, it has been assumed that it would make a safe basis for the minimum yield of the wells described above. Each of the 60-foot shallow wells whose construction is contemplated at the different stations will contain 160 square feet of percolating surface. If the water in the well be lowered 10 feet by the pump, and if the minimum specific capacity of 0.25 gallon per minute be assumed, a yield of 400 gallons per minute is assured for each well. Under a head of 15 feet each well would yield, on the same basis, 600 gallons per minute. The deep well will contain 787 square feet of percolating surface. The specific capacity may safely be taken to be 0.1 gallon per minute per square foot of strainer, instead of 0.25, as finer material may be met with at the greater depths. In making this estimate allowance has been made for 50 feet of clay or silt which will not yield any water at all. The estimate of 0.1 gallon per minute per square foot of strainer under these circumstances is considered the minimum yield, since wells extending through fine clay, fine sand, and miscellaneous material on the uplands average 0.1 gallon per minute per square foot of strainer, counting all the material encountered as water-bearing material. On this basis the yield of the deep well, under 10-foot head, is calculated to be 787 gallons per minute, and under 15-foot head it is calculated to be 1,800 gallons per minute; hence the total capacity for each set of ten wells for 10-foot head will be 4,387 gallons per minute, or 9.75 second-feet, and for the 15-foot head the total yield is estimated to be 6,580 gallons per minute, or 14.6 second-feet. The individual pumping stations are designed on the basis of recovering 5 second-feet of water from each station. The margin of safety on the above estimate is in the ratio of 1 to 3, without counting on a suction head of more than 15 feet.

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[a] Slichter, C S., Underflow of Arkansas River Valley in western Kansas: Water-Sup. and Irr. Paper U. S. Geol. Survey No. 153. (In press.)

On the same basis the total capacity of 23 such stations, under 10-foot head, would be 214 second-feet, and under 15-foot head the total capacity would be 321 second-feet.

Data from tests of pumping plants, Arkansas Valley, Kansas.

1.	2.	3.	4.	5.	6.	7.
Owner of plant.	Location.	Kind of pump.	Horsepower of engine.	Fuel used.	Price of fuel.	Total lift.
					Per gal.	*Feet.*
D. H. Logan	Garden, Kans.	No. 3 centrifugal	6	Gasoline	$0.22	22.1
Mrs. M. Richter	do	Mengo	10	do	.20	15.5
C. E. Sexton	do	2 vertical 6 by 16 cylinder.	1½	do	.22	15.6
Nathan Fulmer	Lakin, Kans.	Chain and bucket.	7	do	.21	17.0
J. M. Root	do	do	2½	do	.22	15.8
King Bros	Garden, Kans.	No. 4 centrifugal	14	Coal		63.0
Waterworks	do	2 duplex steam		do		
I. L. Diesem	do	No. 4 centrifugal	10	Gasoline	.12½	22.13
L. E. Smith	do	do	6	do	.12½	17.6
H. B. Holcomb	Sherlock, Kans.	No. 14 centrifugal.	80	Coal	[a] 4.00	23.0
H. S. Kipp	Garden, Kans.	Two 5 by 5 cylinder	3½	Gasoline	.12½	21.7
J. R. McKinnie	do	No. 4 centrifugal	5	do	.12½	21.47

1.	8.	9.	10.	11.	12.	13.	14.	15.
Owner of plant.	Distance water is lowered.	Yield of well.	Specific capacity of well.	Area of percolating or strainer surface.	Specific capacity per square foot of strainer.	Cost of fuel per acre-foot of water.	Cost of fuel per 1,000 foot-gallons.	Hydraulic horsepower.
	Feet.	*Gals. per minute.*	*Gals. per minute.*	*Square feet.*	*Gals. per minute.*		*Cents.*	
D. H. Logan	6.85	272	42.2	107.0	0.394	$2.93	$\frac{1}{25}$	1.5
Mrs. M. Richter	5.3	394	73.0	266.5	.27	2.90	$\frac{1}{17}$	1.5
C. E. Sexton	3.0	91	30.3	57.2	.53	3.75	$\frac{1}{13}$	.4
Nathan Fulmer	6.36	540	85.0	334.0	.254	1.37	$\frac{1}{40}$	2.3
J. M. Root	4.16	215	51.7	210.0	.246	2.78	$\frac{1}{19}$	.9
King Bros	20.3	183	9.0	85.0	.108			2.9
Waterworks	5.48	290	77.0	247.0	.31			
I. L. Diesem	6.72	363	54.0	151.0	.356	2.10	$\frac{1}{34}$	2.0
L. E. Smith	2.16	198	91.6	70.7	1.290	1.67	$\frac{1}{34}$	.9
H. B. Holcomb	9.60	2,300	240.0	1,876.0	.128	[b] .85	$\frac{1}{90}$	13.4
H. S. Kipp	2.83	96	34.0	45.3	.75	1.09	$\frac{1}{65}$	.53
J. R. McKinnie	8.39	420	50.0	116.0	.42	1.20	$\frac{1}{58}$	2.28

[a] Price per ton.

[b] Including cost of labor and lubricating oil.

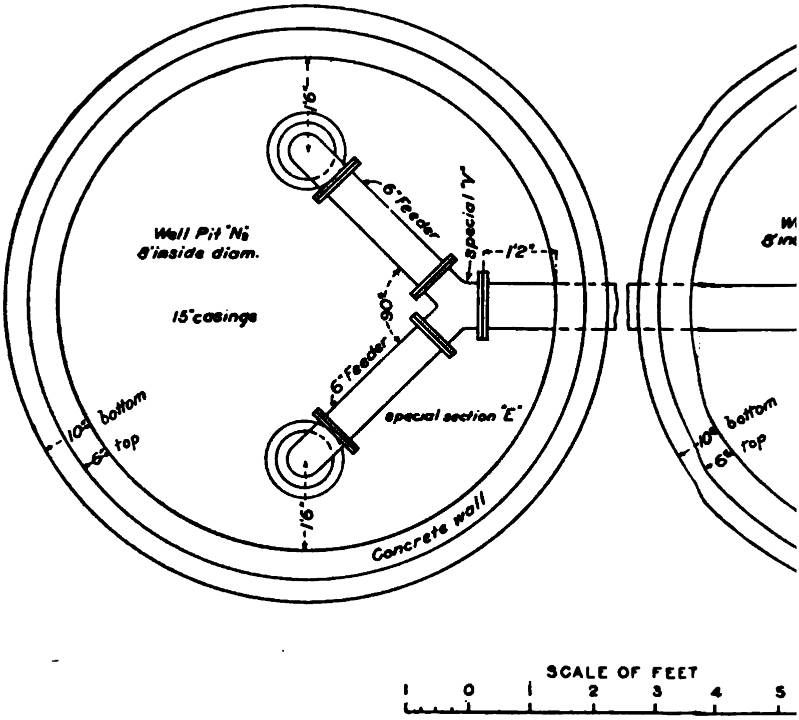
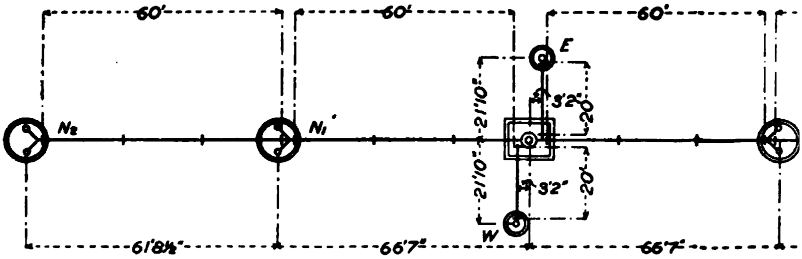


DIAGRAM SHOWING ARRANGEMENT OF WELLS



INDIVIDUAL PUMPING PLAN

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TOTAL AMOUNT OF WATER TO BE RECOVERED.

The entire pumping plant is designed to recover an average of 100 second-feet of ground water for a period of one hundred and fifty days, which is equivalent to a total of 30,000 acre-feet for the irrigation season. The amount of ground water available for this purpose is estimated as follows:

Actual determinations of the rate of flow of the underground waters at this point show an average velocity of 8 feet per twenty-four hours. The total amount of water that passes a cross section 24,000 feet in length and 100 feet deep in these water-bearing gravels will average 6,400,000 cubic feet per twenty-four hours. If we allow for a porosity of one-third in the water-bearing gravels, this is equivalent under normal conditions to a continuous flow of 74 second-feet, or 54,000 acre-feet in a year. It is contemplated, therefore, to utilize a little more than one-half of the ground water that annually passes the cross section intercepted by the proposed line of wells.

The margin of safety provided for above is deemed to be large. In the first place the lowering of the water 10 feet in each of the wells will more than double the natural velocity of the ground waters toward the proposed line of wells; in the second place, in case of a season of light rainfall the amount of storage water which will be drawn upon by the pumping plants will not be excessive, as the 30,000 acre-feet of water whose withdrawal is proposed is equivalent to the average annual contribution of the rainfall to the ground waters on 1.3 townships of these bottom lands. Measurements on these lands during 1904 showed that 60 per cent of the precipitation during moderate rains actually reached the water plane, leaving only 40 per cent to supply the loss and evaporations from the surface. Since the annual rainfall approximates 20 inches, it is contemplated that the normal level of ground water in the contributary area will not be lowered more than 5 feet at the close of an irrigation season. In a dry year an average lowering of the ground water 3 feet for a distance of 5 miles each side of the line of wells would furnish all of the water removed in a season, even if the rainfall and the motion of the underground waters did not furnish a renewed supply.

The bottom lands of the river at this point are very wide and constitute an excellent catchment area for rainfall, and the gravels beneath the bottom lands form an underground drainage for a tributary watershed extending both north and south of the river valley. As has been shown in the writer's report on The Underflow of the Arkansas Valley,[a] there is practically no surface run-off from this portion of the plains. Most of the rainfall occurs during the summer months, and the ground being level and porous, the ample gravels beneath the surface act like tile drains in removing all of the rainfall that is not taken by vegetation and evaporation.

The location selected for the proposed pumping plant is well adapted to catch and conserve a considerable portion of the annual rainfall. This is especially true of the land south of Arkansas River. At this place large areas of flat land lie between the steeper sand hills, which catch the rainfall and naturally drain it toward the region from which it will be drawn by the pumping plant. This fact is well illustrated by the topographic map of the Lakin quadrangle, which shows that the sand hills at the head of the line representing the line of wells form an unusually favorable catchment area.

CENTRAL POWER STATION.

The central power station is designed to develop 600 brake horsepower from gas engines using producer gas as fuel or from steam engines using Kansas crude oil or Colorado bituminous coal as fuel. Colorado lignite suitable for producer gas can be laid down at the proposed location for less than $3.50 per ton. It is proposed to erect a gas-producer plant in two or three units, as it is probable that two units would run the plant for a considerable portion of the time. It is planned to divide the engines into three units of 200 horsepower each, directly connected to electrical generators.

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[a] Water-Supply and Irrigation Paper No. 153, U. S. Geol. Survey.

The following table gives the lift required at each station and the power required to run the plant.

Lift at various pumping stations and power required.

1.	2.	3.	4.	5.
Station.	Water in canal above water plane.	Discharge above water plane.	Total lift; suction = 12.	Total lift; suction = 12 and 9.
	Feet.	*Feet.*	*Feet.*	*Feet.*
50	5.5	6.5	18.5	18.5
40	5.5	6.5	18.5	18.5
0	5.5	6.5	18.5	18.5
10	5.0	6.0	18.0	18.0
20	5.2	6.2	18.2	18.2
30	4.5	5.5	17.5	17.5
40	4.7	5.7	17.5	17.5
50	4.8	5.8	17.8	17.8
60	4.0	5.0	17.0	17.0
70	4.0	5.0	17.0	17.0
80	10.0	11.0	23.0	20.0
90	9.5	10.5	22.5	19.5
100	8.4	9.4	21.4	18.4
110	7.3	8.3	20.3	17.3
120	9.5	10.5	22.5	19.5
130	8.5	9.5	21.5	18.5
140	8.0	9.0	21.0	18.0
150	7.7	8.7	20.7	17.7
160	7.6	8.6	20.6	17.6
170	6.0	7.0	19.0	16.0
180	6.5	7.5	19.5	16.5
190	5.8	6.8	18.8	15.8
200	3.5	4.5	16.5	13.5
Total			445.8	406.8
Average			19.4	17.7
Required horsepower			254	230
Brake horsepower			650	590

Pump-motor-line-generator efficiency (60, 85, 90, 85) = 39 per cent.

FUEL.

An analysis of Colorado lignite believed to be suitable for producer fuel is given herewith:

Analysis of lignite from mine of Curtis Coal Mining Company, Colorado Springs, Colo.

[Analysis made at fuel laboratory, University of Wisconsin, February 10, 1905.]

1.	2.	3.	4.	5.
Sample.	Moisture.	Volatiles.	Fixed carbon.	Ash.
1	23.3	37.1	36.6	2.9
2	23.1	30.9	42.7	2.3
3	21.6	38.8	36.4	3.2
Average	22.7	35.6	38.6	3.1

The ash is free from slag. After combustion it is left in a fine powder similar to hardwood ashes.

The British thermal units in two determinations amounted to 11,700 in the first and 12,000 in the second per pound of dry sample.

INVERTED SIPHON.

A portion of the water recovered must be carried under Arkansas River by means, it is proposed, of a 42-inch stave pipe held in place beneath the bed of the river by 40-foot piling. This conduit is provided with north and south penstock approaches of concrete. The total length of the siphon is 800 feet, and its capacity, under the proposed head of 5 feet in 800, is 100 cubic feet of water per second.

CONCRETE CONDUIT.

The topography of the land near the proposed plant is such that the conduit to receive the water from the various pumping plants can be constructed with very little grading or excavation. At the point where the conduit discharges into the Farmers' ditch it will have a maximum capacity of 120 second-feet. It is proposed to construct the conduit of trapezoidal cross section and line it with 4 inches of concrete. Three of the pumping plants will discharge directly into the Farmers' ditch, so that the total maximum capacity of the entire plant will be about 135 second-feet. The Farmers' ditch has been in use for several years, and its bottom has been so thoroughly puddled with mud from the river that it is not necessary to line it in order to avoid excessive loss of water by seepage. The conduit will decrease in size gradually toward the end of the line, so as to reduce the total cost. South of station 16 the grade permits the conduit to be placed beneath the surface, and its design is accordingly changed to a rectangular section.

CONCRETE.

Concrete for all purposes will be made from sand and gravel found in the vicinity of the conduit line on the south side of the river. The voids in the natural gravels run as low as 20 per cent, so that the amount of cement required for good concrete will be low. Cement for concrete can be put down at Deerfield at a low price. The current quotation for Iola cement, best quality, satisfying the Government specifications, is $1.57 per barrel.

PUMP HOUSES.

The motor and centrifugal pump will be housed in a suitable structure built over the central rectangular pit of each pumping station. The construction contemplated is of concrete reenforced with steel rods.

On account of occasional flooding of the lands on which the pumping stations are located a vertical type of pump and motor is required for the proper protection of the motor. The motor will either be supported by a cast-iron frame connected to the pump, so that pump and motor will stand on the same base, or will be suspended in steel channels.

A 7-inch I beam, extending just below the roof line, will serve as an overhead rail to carry the trolley of differential chain hoist, by means of which the pump or motor can readily be removed from the building.

On account of the large amount of sand and dust carried by the wind in a semiarid country it becomes especially important to protect all machinery with the greatest care. For this reason the pump house is designed to be built so that it can be kept tight, the necessary ventilation being provided by two round windows placed at a considerable distance from the ground, and provided with gauze screens and louver boarding.

The estimate of cost includes 4-ply tar or paroid covering on flat roof and removable sectional floor of 2-inch yellow pine.

LAND RECLAIMED.

The Farmers' ditch covers portions of the uplands and second bottoms of excellent and proved quality. At least 15,000 and possibly 20,000 acres of land can be reached from the present canal. The canal and laterals are in good condition and are worth about $40,000. The water to be recovered by the pumping plant is designed to irrigate the 8,600 acres of land entitled to water under the existing ditch. The semiarid region of western Kansas requires but a small amount of water per acre of irrigated land, as the natural rainfall and the quality of the upland soils render possible a high duty of water. If more water is available than is counted upon above, there is ample acreage that can be included in the project at a later date.

COST PER ACRE RECLAIMED.

According to the detailed estimates the cost of the proposed project will be about $30 per acre of land reclaimed, and the running expense of the plant need not exceed 77 cents for each acre-foot of water delivered. The estimated cost of the project is based upon the use of a producer-gas plant and gas engines for prime movers, and a distributing system consisting of direct-current generators and motors. The estimated cost for steam engines and alternating-current machinery would be less than the amount included in the estimate given herewith. It will be observed from the detailed statement of operating expense that the annual expense has been divided into two portions—first, fixed charges, including depreciation, maintenance, and repairs, which must be met irrespective of the quantity of water pumped; second, operating expenses, such as labor, coal, supplies, and cost of distribution, which will depend primarily upon the amount of water pumped. It is proposed to charge each of these classes to the land reclaimed as separate items. The first will be a fixed charge of approximately 75 cents for each acre of land under the project, whether the owner uses water or not. The second charge will be for distributed water, the cost of which, based upon a total of 25,000 acre-feet delivered to the users, will be 77 cents per acre-foot. This charge will be in proportion to the amount of water used.

The lands to be reclaimed are known to be excellent for the growing of sugar beets, and considerable quantities are grown at the present time and shipped to Colorado factories. This crop will probably become one of the staples grown on the reclaimed land. A market and knowledge of the requirements already exist in the community, and will not have to be developed by experience. A sugar factory will be completed at Garden City before the autumn of 1906. One or two irrigations at the right time assure a crop of wheat, and the estimated cost of water will by no means render such a crop unremunerative.

PRESENT STATUS OF PROJECT.

Preliminary plans and estimates for the Garden City project were submitted to a project board, consisting of A. P. Davis, H. A. Storrs, and Charles S. Slichter, which met at Denver on March 24, 1905. This board recommended that the surveys and investigations be continued and that alternative estimates of several possible designs and limiting sizes be prepared for future consideration. These further plans and estimates were considered by a project board on September 5, 1905, at Garden City, Kans. The board consisted of Morris Bien, W. H. Sanders, O. H. Ensign, H. A. Storrs, and Charles S. Slichter. This board recommended, first, that the project be constructed as soon as the water users' association had been organized in satisfactory form and practically the entire area of the land under the project had been subscribed to the water users' association; second, that the preparation of plans and specifications for construction be undertaken at once, so that there should be no delay in beginning construction after the organization of the water users' association had proceeded to the proper stage. Under date of October 5, 1905, the Secretary of the Interior approved the project and ordered its construction as soon as practicable after the complete subscription in the usual manner of all the lands to be benefited in order to insure the return of the fund, in accordance with the reclamation act.

OPERATIONS IN MONTANA.

By H. N. Savage.

MILK RIVER PROJECT.[a]

GENERAL FEATURES.

The location and extent of the Milk River project were described in the First Annual Report of the Reclamation Service, pages 203 to 214; in the Second Annual Report, pages 332 to 350, and in the Third Annual Report, second edition, pages 291 to 307. A general map of the project was published in the Third Annual Report, second edition, as Pl. XXVIII.

In northern Montana and southern Alberta are two rivers, Milk and St. Mary rivers, that are international in character, their drainage basins being partly in the United States and partly in Canda. Canals have been diverting water from each river for several years past, and certain vested water rights have thus been acquired.

St. Mary River rises on the eastern slope of the Rocky Mountains in Montana and flows northward into Canada, where it empties into Saskatchewan River, its waters being eventually lost in Hudson Bay. Milk River has its source in the United States, in the rolling country lying immediately east of the St. Mary basin. Its two forks, North and South forks, flow northward into Canada, where they unite, thence continuing as Milk River proper in an easterly direction for about 100 miles, and then reentering the United States. Milk River finally empties into the Missouri.

The valley of lower Milk River ranges in elevation from 2,100 to 2,500 feet, and is well adapted to irrigation if the water supply were sufficient. Milk River is deficient in this particular, and the Reclamation Service proposes to reinforce it with an additional supply from St. Mary River.

Plans are now maturing in both countries for larger irrigation works, whereby ultimately the water supply of both rivers will be utilized, and it will probably be necessary for the United States and Canada to make an agreement relative to a division of the waters of both streams.

The general scheme of the Reclamation Service is divided into two parts: (1) Storage of the flood waters of St. Mary River and their diversion into the headwaters of Milk River; and (2) the utilization of this water on the irrigable lands of lower Milk River in Montana.

The investigation has brought out three methods of utilizing the waters of St. Mary basin: (1) By diverting St. Mary River to North Fork of Milk River and allowing it to run through Canada to lower Milk River Valley in Montana. (2) By utilizing the waters on the eastern section of the Blackfeet Indian Reservation and on the lands immediately adjacent to the east. (3) By carrying the St. Mary water across both the North and South forks of Milk River to Cutbank drainage, allowing it to flow down this and Marias River, 100 miles or more, then taking it out of the Marias by a canal to Big Sandy Creek, a tributary of Milk River.

The most feasible project is the one first mentioned. The second scheme can also be carried out. The third method has been considered in previous reports as a possible connecting link between the St. Mary basin and lower Milk River, but from the detailed investigation on Marias River during 1904 it is believed that this diversion should be considered on its own merits—that is, as a scheme to make the Marias a separate source of irrigation for lands immediately west of Big Sandy Creek.

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[a] From report by Cyrus C. Babb.

IRRIGABLE AREA.

The Milk River project as designed contemplates reclaiming over 250,000 acres, divided into two diversions: (1) 91,970 acres near Chinook; (2) 158,900 acres extending from the Dodson diversion dam eastward to Glasgow. The following table shows areas that can be reclaimed under these systems:

Areas under Milk River system.

		Acres.
Chinook system:		
Chinock North canal, 38.3 miles		44,000
Chinook South canal, 57 miles—		
West of Indian reservation		14,975
On Indian reservation		32,995
		91,970
Dodson system:		
Malta South canal,	31 miles	20,671
Malta North canal,	30 miles	14,021
Beaver Creek canal,	32 miles	13,894
Bowdoin North canal,	65 miles	46,127
Bowdoin South canal,	84 miles	48,370
Hinsdale canal,	35 miles	13,723
Mud Lake outlet,	10 miles	2,094
Total,	287 miles	158,900
Grand total		250,870

The areas under the Marias canal system are shown in the table below. There is included 19,750 acres, which can be reclaimed by additional pumping to a height of 20 or 25 feet.

Areas under Marias system.

	Acres.
Marias High Line canal, 150 miles	102,680
South canal, 18 miles	13,670
West Reservoir canal, 60 miles	30,160
East Reservoir canal, 38 miles	33,740
Total	180,250
Pumping	19,750
Grand total	200,000

ST. MARY BASIN.

St. Mary River has its source on the eastern slope of the continental divide. The snow-capped peaks of the range and the many glaciers in the basin contribute to the high run-off and a large water supply. The plan of the United States Reclamation Service is to connect this mountain drainage area by means of a canal 23 miles long with the headwaters of Milk River and to utilize the increased water supply for the irrigation of the lower valley of this latter stream.

WATER SUPPLY.

Gaging stations have been maintained in St. Mary basin since 1902 on St. Mary River at the dam site, on Swiftcurrent Creek at its mouth, and on St. Mary River at the international boundary line. Occasional measurements were made on Kennedy Creek near its mouth. A gaging station was established by the Alberta Railway and Irrigation Company in 1905 on St. Mary River at Kimball, Alberta, immediately above the head of the Canadian canal. The following table shows the total annual discharge in acre-feet at the stations maintained by the United States:

Annual discharge of St. Mary River, in acre-feet.

River.	Location.	1902.	1903.	1904.	1905.
St. Mary	Dam site	477,913	539,070	399,614	306,920
Swiftcurrent	Mouth	224,832	290,385	194,734	162,544
St. Mary	International line	....	1,107,294	610,409	514,100

CANADIAN DIVERSION.

In 1900 a canal was completed in Canadian territory diverting water from St. Mary River about 7 miles north of the international line. It is the property of the company then known as the Canadian Northwest Irrigation Company, but now known as the Alberta Railway and Irrigation Company. The total length of the canal system is 200 miles, including laterals; the length of the main canal is 86 miles, including 27 miles of natural channel. The main canal at the head is 20 feet wide on the bottom, 5 feet deep, side slopes 1½ to 1, and grade 2 feet to the mile. With these dimensions, the capacity of the canal would be about 385 second-feet. The maximum capacity as measured in July 22, 1905, was 311 second-feet. The government grant to this company on St. Mary River was 500 second-feet of the low-water discharge and 2,000 second-feet of the flood discharge, with a time limit of fifteen years in which to complete the works.

The company has also a land grant of 600,000 acres from the Dominion Government, provided it applies water to same. In order to perfect title to the land, the company has developed the St. Mary and Milk River irrigation systems, described above. It has also under construction the development of a storage system. There are no reservoirs directly on the two main streams, but there are a number throughout the area controlled by the canals. The system as at present constructed does not utilize these reservoirs, but it may be possible to utilize them by enlarging the canals at considerable expense.

CUTBANK AGRICULTURAL AREA.

The eastern part of the Blackfeet Indian Reservation and the country immediately east of it is well adapted to irrigation. During 1904 a topographic reconnaissance was made of this section, and the total area of 164 square miles was covered. Sixty-seven per cent of this area, or 70,000 acres, is a level tract of good soil. At present there is no available water supply immediately near it, but it is possible to carry St. Mary water to the area. In order to do this, St. Mary canal, above described, would have to be extended, first across the North Fork of Milk River, then to and across the South Fork to the top of the ridge, or the divide between South Fork of Milk River and the Rocky Coulee drainage, a tributary of the Marias. The total length of this canal would be 60 miles. The water would be turned into Little Rocky Coulee, down which natural channel it could flow for a few miles and then be diverted to the agricultural lands.

In addition to the area just given—70,000 acres, or that up to the 4,000-foot contour—there are similar additional areas above that could be watered from the same supply. The total area in this vicinity thus available for agricultural purposes is 100,000 acres. The general range in altitude is from 3,700 to 4,000 feet above sea level. (See Pl. XX.)

DIVERSION OF CUTBANK CREEK.

From a study of the resulting surveys of the Cutbank agricultural area another possible project may have been discovered. This is the diversion of Cutbank Creek at a point about 17 miles west of the town of Cutbank on the north side of the creek. The elevation of the water surface at the proposed diversion is 3,880 feet. At the end of the seventh mile the canal would be out of its canyon and would then commence to cover the irrigable land. The total length of the projected canal is 58 miles, and the total area under it is 31,000 acres. About 75 per cent of this area is irrigable land, leaving a net area of 24,000 acres that could probably be irrigated.

A private company has been contemplating the development of this project, but with a canal heading somewhere several miles downstream from the point of diversion proposed. This canal would irrigate about 10,000 acres. (Pl. XX.)

A gaging station was established on Cutbank Creek at the town of Cutbank on August 4, 1905. The records are not of sufficient length to permit an estimate of the water supply of this stream, as they do not cover the flood stage of the creek in May and June. It is believed, however, that there is enough water in the stream to supply a canal having a capacity of 250 second-feet, the amount of water that will be required in this contemplated project.

The storage possibilities for this line are not very good. Cutbank Creek has too great a fall to permit the economical construction of reservoirs. A few small sites on the agricultural land itself may be discovered by a detailed survey.

ST. MARY RESERVOIR CAPACITIES.

The first plan for storage on St. Mary Lakes involved the construction of one earthen dam about 50 feet high at the outlet of the lower lake. Lately consideration has been given to the construction of a dam between the lakes, or at the outlet of the upper lake, and studies of various heights at both locations have been made. The difference of elevation between the two lakes is 12 feet, the elevation of the surface of the lower one being 4,460 feet and of the upper 4,472 feet. The distance between the lakes is about 1½ miles. Provisions for lowering the upper to the level of the lower lake have also been studied.

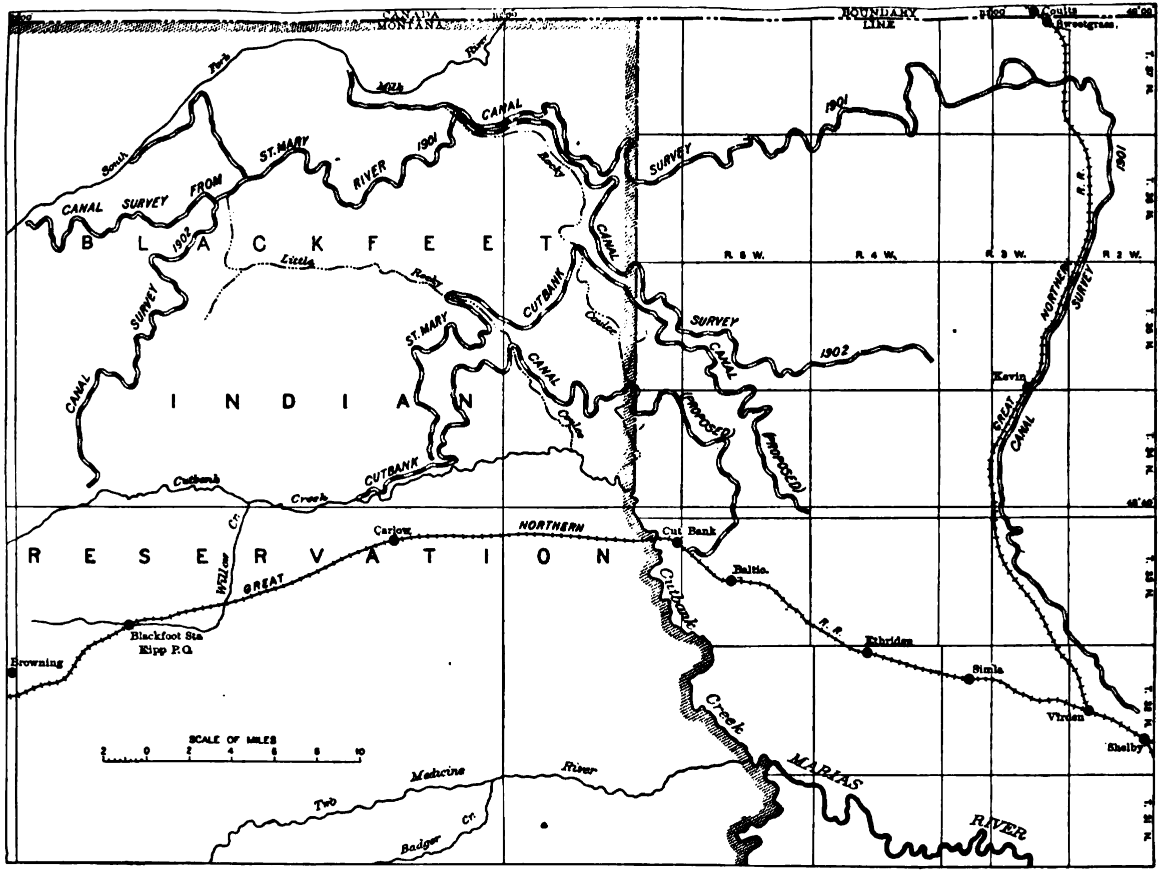
PROPOSED PLANS.

It is proposed to store the flood waters of St. Mary River by constructing one or more earthen dams at the outlet of the St. Mary Lakes, and conducting the water by means of a canal 24 miles long to the North Fork of Milk River. This canal will be located entirely in the United States. The first 6 miles along the canyon side of St. Mary River will be lined with cement and will have the following dimensions: 7 feet wide on the bottom; 7.3 feet deep; side slopes, 1½ to 1; grade, 0.00125, or 6.60 feet to the mile; discharge, 1,000 second-feet. For the unlined portion the section will be as follows: Bottom width, 26 feet; depth, 9 feet; side slopes, 1½ to 1; grade, 0.0002.

The dimensions of the dam at the outlet of the lower lake will be as follows: Length on top, 1,600 feet; slopes on both upper and lower sides, 3 to 1; elevation of crest, 4,498; effective height of dam, 31 feet. Provision is also made for excavating the channel between the upper and lower lake, so that the former can be drawn down to the elevation of the latter lake. The reservoir capacity under these conditions will be 150,000 acre-feet.

INTERNATIONAL CANAL.

The attention of the Reclamation Service was brought by the Canadian officials to a possible canal line from St. Mary River, located partly in the United States and partly in Canada, that might be less costly than the all-American canal. Preliminary surveys of this international canal were made in 1905. It heads at what is known as the Paisley dam site, about 3 miles south of the international line. It thence extends into Canada, through which it continues for about 8 miles, swinging back into the United States and around Willow Creek



CUTBANK CREEK AGRICULTURAL AREA, ST. MARY BASIN, MONTANA.

drainage for 4½ miles, finally ending in Whiskey Gap, in Canada, whence the water finds its way into the drainage of the North Fork of Milk River. The total length of the canal line is 23 miles. Preliminary estimates show that this canal would be somewhat cheaper of construction than the upper line, and the annual maintenance would also probably be less.

LOWER MILK RIVER BASIN.

Milk River, when it reenters the United States, flows southeastward for about 60 miles and then continues in a general eastern direction for 170 miles until it enters Missouri River. The valley is comparatively narrow, ranging from one-half mile to 1 mile in width from the international line to a point about 10 miles east of Havre, when it widens out and has an average width of 3 miles down to its mouth.

The general plan for the irrigation of the valley comprises the construction of the Chain Lakes reservoir, the upper end of which is only a few miles below the international line. This reservoir will store the flood waters of Milk River and any of the stored waters of St. Mary River that may be turned into it. The water will be turned out of the reservoir and allowed to continue down the main channel of Milk River. Two diversion systems are planned for the valley, one, known as the Chinook system, comprising the Chinook North and south canals, heading 3 miles southeast of the town of Chinook, and the other, known as the Dodson system, comprising two canals from either bank of the stream, heading about 22 miles west of the town of Malta. The various areas under these systems are shown in the table on page —.

WATER SUPPLY.

A number of gaging stations have been maintained on Milk River in the United States. The one at Havre was established in 1898, and the one at Malta in 1903. Both have been maintained to date. Stations have also been established on the private canals near Chinook and Harlem, Mont.

The following table shows the total annual run-off at Havre and Malta:

Run-off of Milk River by years at Havre and Malta, Mont.

Year.	Havre.	Malta.	Year.	Havre.	Malta.
	Acre-feet.	*Acre-feet.*		*Acre-feet.*	*Acre-feet.*
1898	205,146	....	1902	426,226	....
1899	402,512	....	1903	306,516	404,076
1900	111,202	....	1904	165,214	280,577
1901	162,788	....	1905	17,110	31,070

In May, June, and July, 1904, measurements of Milk River in Canada, above the head of the Canadian canal, were made by the Alberta Railway and Irrigation Company. These measurements showed that the discharge at that point was 80 per cent of the discharge at Havre. It is understood that a regular station was maintained in 1905 on Milk River, above the head of the Canadian canal. The United States is not at present in possession of the results.

In May, 1905, a station was established on the South Fork of Milk River on the Blackfeet Indian Reservation in Montana. The greater percentage of the flow of Milk River at the Canadian canal is contributed by this tributary, but this percentage can not be determined until the Canadian measurements are made available.

In June, 1905, a series of measurements were made on Milk River from the head of the Canadian canal down to Havre in order to determine the seepage losses, if possible. This year was extremely dry, and as a consequence Milk River was lower than it had been for years.

The following table shows the results of these measurements:

Seepage measurements on Milk River in Canada and Montana.

Date.	Location.	Distance between points.	Discharge.	Gain or loss	
				Total.	Per mile.
1905.	CANADA.	*Miles.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
June 9	Canadian headgates near Coutts	0	49.0	....	....
June 9	Railroad crossing, Milk station	10	56.5	7.5	0.75
June 10	Logan's ranch	16	51.4	—5.1	—.32
June 10	Young's ranch	10	47.2	—4.2	—.42
June 10	Suckler's ranch	14	43.9	—3.3	—.24
June 6	International line, Montana	75	39.9	—4.0	—.05
June 6	Simpson's ranch	15	37.0	—2.9	—.20
June 5	Chain Lakes dam site	19	33.3	—3.7	—.20
June 5	Deserted ranch	15	41.6	+8.3	+.55
June 5	Havre	10	44.6	3.0	.30

PRIVATE CANALS IN CANADA.

A canal completed in November, 1904, heads from Milk River, in Canada, about 12 miles below the junction of North and South forks and about 10 miles above the crossing of the Alberta Railroad. The dimensions of the canal are as follows: Bottom width, 25 feet; depth, 5 feet; side slopes, 1½ to 1; grade, 0.0002; computed discharge, 330 second-feet. The water is required to supplement the irrigation system from St. Mary River, described elsewhere, and will irrigate lands lying east of the Alberta Railroad. Water was turned into this canal for two days in November, 1904, simply to test the canal. On account of the low stage of Milk River in 1905 no water was turned in that year.

The Canadian irrigation law gives the minister of the interior the power to permit companies or individuals to appropriate the waters of the rivers, and also provides a time allowance in which the grantee shall complete his works and beneficially apply his water. In the case of Milk River the Alberta Railway and Irrigation Company has a right to 500 second-feet of the low-water flow and 1,500 second-feet of the flood flow. This company also has fifteen years in which to complete its development.

PRIVATE CANALS IN MONTANA.

A number of canals from Milk River, in the vicinity of Harlem and Chinook, have been in operation for several years. The following table gives certain data relative to them. The first five canals divert directly from Milk River, and the five latter ones from tributaries. Rock Creek ditch is in the vicinity of Hinsdale.

Private canals in Milk River basin, Montana.

CANALS DIVERTING DIRECTLY FROM MILK RIVER.

Canal.	First used.	Capacity claimed.	Capacity measured.	Area under ditch.	Area irrigated, 1904.	Total discharge.	
						1904.	1905.
			Sec.-feet.	*Acres.*	*Acres.*	*Acre-feet.*	*Acre-feet.*
Fort Belknap	1894	750	130	14,632	10,900	16,678	13,969
Paradise	1895	50	19	3,295	1,400	1,902	1,974
Winters-Anderson	1900	100	12	1,318	440	....	....
Harlem	1895	1,250	73	11,000	7,820	7,256	5,564
Indian reservation	1901	125	125	15,000	1,000	....	2,204
Total	....	2,275	359	45,245	21,560	25,836	23,711

Private canals in Milk River basin, Montana—Continued.

MISCELLANEOUS CANALS.

Canal.	First used.	Capacity claimed.	Capacity measured.	Area under ditch.	Area irrigated, 1904.	Total discharge.	
						1904.	1905.
			Sec.-feet.	*Acres.*	*Acres.*	*Acre-feet.*	*Acre-feet.*
Cook Irrigation Co., north fork	1895	75	50	5,639	2,700	....	4,628
Matheson Ditch Co., north fork	1892	125	28	2,520	1,715	....	2,575
West Fork Ditch Co.	1899	100	13	1,479	800	....	....
Reser ditch	1900	50	8	400	240	....	....
Rock Creek Co.	1904	120	48	9,000	....	....	....
Total	....	475	147	19,038	5,455	....	7,203

A law suit for the adjudication of the water rights of these canals and others in the Milk River Valley is now pending.

CHAIN LAKES RESERVOIR.

By the construction of a dam 92 feet in height in Milk River, at a point 30 miles northwest of Havre, a reservoir can be created with a capacity of 466,950 acre-feet.

The following table shows the capacity for this reservoir for various heights of dam:

Capacity of Chain Lakes reservoir site.

Contour.	Area.	Capacity of section.	Total capacity.	Top length of dam.
Feet	*Acres.*	*Acre-feet.*	*Acre-feet.*	*Feet.*
2,560	569	....	....	1,820
2,570	1,454	10,110	10,110	1,970
2,580	3,271	23,620	33,730	2,020
2,590	5,174	42,220	75,950	2,060
2,600	6,834	60,040	135,990	2,110
2,610	9,139	79,860	215,850	2,140
2,620	10,891	100,150	316,000	2,170
2,630	13,422	121,560	437,560	2,210
2,632	13,932	....	466,950	....
2,640	15,971	146,960	584,520	2,250
2,650	18,359	171,650	756,170	2,280

The dam will be located in sec. 17, T. 34 N., R. 13 E. It will be an earth structure 92 feet in height, with top length 2,250 feet, and slopes 3 to 1 on the upper and 2 to 1 on the lower side. The general elevation of the river bottom at this point is 2,555 feet, making the top of the dam an elevation of 2,647 feet. The elevation of the spillway will be 2,632 feet. The top width of the dam will be 15 feet. With these dimensions the total contents of the dam will be 1,727,550 cubic yards. The spillway will be in sec. 9, T. 33 N., R. 13 E., at the lower end of what is known as Chain Lakes. The water in this spillway will discharge into the river about 8 miles below the main dam.

CHINOOK DIVERSIONS.

During 1902 a survey of what is known as the Yantic canal was made, heading on the north side of Milk River, in sec. 36, T. 33 N., R. 17 E., and continuing eastward for 54 miles. In 1904 a canal on the south side of the river was run called the Chinook south canal, heading in sec. 6, T. 32 N., R. 20 E., 3 miles southeast of the town of Chinook. It continued eastward through the Fort Belknap Indian Reservation for a total distance of 57 miles. Its length, from the head to the western edge of the reservation line, was 15 miles, and in this distance it will cover 14,975 acres. There are 32,995 acres on the reservation itself, making a total area under the canal of 47,970 acres.

These two diversions will necessitate two separate dams, 13 miles apart, the one at Yantic 14 feet high and at Chinook 14 feet high. From a study of the detailed maps, it is considered best to abandon the Yantic diversion, and in its place to take a canal from the north end of the Chinook dam. The area that will thus be omitted is 19,500 acres. It is practically all served, however, at present by the Fort Belknap canal, one of the private canals of this vicinity.

The dimensions of the Chinook north canal at the head are as follows: Width, 30 feet; depth, 6.9 feet; side slopes, 1.5 to 1; grade, 0.0001; discharge, 515 second-feet. The total length of canal is 38.1 miles, and the area covered is 44,000 acres. The elevation of the bottom of the canal at the head will be 2,383 feet.

The Chinook south canal at the head will have the following dimensions: Bottom width, 30 feet; depth of water, 6 feet; side slopes, 1.5 to 1; grade, 0.0002; discharge, 540 second-feet. The elevation of the bottom of the canal at the head will be 2,384 feet. The diversion dam will be of concrete, with a long concrete apron at the lower end. The elevation of the top of the dam will be 2,390, and the length on top 250 feet.

DODSON DIVERSION.

The general plan of diversion here contemplates the construction of a concrete overflow dam, with a maximum elevation above the river of 29 feet. The length of the crest will be 250 feet. It is located 23 miles west of Malta, and about 3 miles west of Dodson station, on the Great Northern Railroad. The average depth to bed rock at this site is about 60 feet. The concrete dam will be founded on piles, with a row of wooden sheet piling at the upper edge extending down to bed rock. The elevation of the top of the dam will be 2,285 feet. Water will be diverted from either end of the dam, the canal from the north end being known as the Malta north canal, and from the south end, Malta south canal. From the south end of the dam an earth embankment 6,500 feet in length, and with a maximum height of 15 feet, will have to be constructed across the flat to the foothills on the south side.

During flood stages of the river certain private lands will be flooded for short periods, and it will therefore be necessary for the Government to purchase them. A portion of the track of the Great Northern Railroad will have to be raised.

MALTA NORTH CANAL.

From the north end of this dam this canal will be diverted to irrigate 14,000 acres of land between the head and about 6 miles northeast of Malta. The dimensions at the head are as follows: 15 feet wide on the bottom; 4.5 feet depth of water; side slopes, 1.5 to 1; grade, 0.00025; discharge, 200 second-feet; length, 30 miles.

MALTA SOUTH CANAL.

The first design for this canal had a capacity of 2,000 cubic feet a second, and was to be used as a feed canal to carry flood waters of Milk River to Bowdoin reservoir. Owing to the discovery of the Chain Lakes reservoir, the Bowdoin reservoir has been abandoned for the present, and the Mud Lake site is to be used instead. It was also possible to reduce the capacity of the canal to 800 cubic feet per second. The dimensions of the first section, extending from station 0 to station 600, are as follows: Bottom width, 27 feet; depth of water, 7 feet; side slopes, 1.5 to 1; grade, 0.0003. The second section, extending from station 600 to station 2105, will have the following dimensions: Bottom width, 30 feet; depth of water, 8.8 feet; side slopes, 1.5 to 1; grade, 0.0001. The third section, from station 2105 to 2200, has a considerably reduced area, on account of the heavy cut that is necessary. The end of this section is at Mud Lake reservoir. The dimensions of the canal are as follows: Bottom width, 14.4 feet; depth, 8.8 feet; side slopes, 1.5 to 1 below water surface and 1 to 1 above the water surface; grade, 0.00032. The total length of the canal from the head to the Mud Lake reservoir will be 41.7 miles.

MUD LAKE RESERVOIR.

This site is located in Tps. 31 and 32 N., Rs. 31 and 32 E. The capacities to various heights are shown in the following table:

Capacities of Mud Lake reservoir site.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
2,180	438	0	0
2,185	554	2,480	2,480
2,190	839	3,480	5,960
2,195	1,143	4,955	10,915
2,200	1,778	7,300	18,215
2,205	1,984	9,405	27,620
2,210	2,546	11,325	38,945
2,215	3,638	15,460	54,405
2,220	4,424	20,155	74,500
2,225	5,247	26,940	101,500
2,230	5,870	28,750	130,250
2,235	6,383	29,780	160,030
2,240	6,842	30,400	190,430

In order to create this reservoir it will be necessary to build an embankment 15,135 feet long, dimensions of which are as follows: Elevation of top, 2,245 feet; width on top, 16 feet; upper slope, 3 to 1; lower slope, 2 to 1. The maximum height will be 33 feet. The total yardage, with these dimensions, will be 911,540 cubic yards.

The elevation of the water surface when the reservoir is filled will be 2,240 feet. The capacity at this height, as given in the table above, will be 190,430 acre-feet. It will be necessary, however, to divert the water at the 2,195-foot elevation, and this will give a capacity of 179,515 acre-feet.

RESERVOIR CANALS.

During 1904 surveys were made for canals on the north and south sides of Milk River, extending from Bowdoin reservoir to Glasgow. With slight modifications at the head these can be utilized for canals from the Mud Lake reservoir.

North reservoir canal will have at the head the following dimensions: Bottom width, 25 feet; depth of water, 6 feet; side slopes, 1.5 to 1; grade, 0.0003; discharge, 560 second-feet. It will be 65 miles long and will cover 46,127 acres.

South reservoir canal will have at the head the following dimensions: Bottom width, 30 feet; depth, 6.4 feet; side slopes, 1.5 to 1; grade, 0.0002; discharge, 615 second-feet. It will be 84 miles long and will cover 48,370 acres.

MARIAS PROJECT.

During the earlier stages of the investigation the development of Marias River was considered as a connecting link between the St. Mary basin and the lower Milk River Valley. As a result of later surveys it is now believed best to consider the diversions from Marias River as a separate project not connected with the Milk River project.

STORAGE.

During 1902 an investigation into the storage possibilities of the upper Marias basin was made. The most important site was that of Two Medicine Lake, which was surveyed in detail. The following table shows the capacities of this site at various heights of dam:

Capacity of Two Medicine Lake reservoir site, Montana.

Contour.	Area.	Capacity of sections.	Total capacity.	Top length of dam.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*	*Feet.*
4,850	1.5	....	....	....
4,854	352.5	708	708	65
4,860	538.4	2,673	3,381	172
4,870	722.7	6,305	9,686	453
4,880	854.0	7,884	17,570	700
4,890	1,004.5	9,293	26,863	960
4,900	1,100.8	10,527	37,390	1,225
4,910	1,187.3	11,441	48,831	1,505
4,920	1,260.3	12,238	61,069	1,640
4,930	1,330.2	12,952	74,021	1,940
4,940	1,393.1	13,617	87,638	2,150

The total annual yield of Two Medicine River will approximate 100,000 acre-feet.

Topographic surveys of the Marias Canyon were begun in 1902 on a scale of one-fifth of a mile to the inch, with a contour interval of 20 feet, extending from the crossing of the Great Northern and Montana Railroad to the mouth of Cottonwood Creek. During 1904, early in the season, this work was continued by making a reconnaissance map on a scale of 2,000 feet to 1 inch of the river canyon from Cottonwood Creek to below the mouth of Black Coulee. The results of this reconnaissance showed that the best location for a dam is in what is known as the Sandstone Canyon of the Marias, almost exactly on the range line between Rs. 7 and 8 E.

The following table shows the capacity of the Marias River reservoir for different heights of dam:

Capacity Marias reservoir site.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
2,710	670	4,850	4,850
2,720	1,039	8,545	13,395
2,730	1,771	14,050	27,445
2,740	2,502	21,365	48,810
2,750	3,451	29,765	78,575
2,760	4,401	39,260	117,835
2,770	5,276	48,385	166,220
2,780	6,150	57,130	223,350
2,790	7,293	67,215	290,565
2,800	8,436	78,645	369,210
2,810	9,646	90,410	459,620
2,820	10,857	102,515	562,135
2,830	11,987	114,220	676,355
2,840	13,117	125,520	801,875
2,850	14,720	139,185	941,060
2,860	16,323	155,215	1,096,275
2,870	18,656	174,895	1,271,170
2,880	20,989	198,225	1,469,395

In August detailed surveys were begun, and consisted of mapping the dam site on a scale of 100 feet to the inch, with 5-foot contours, and of the canyon itself on the same scale from the dam site to the divide between Marias drainage and Big Sandy Creek. Diamond-drill borings were also taken across the line of the dam, the located spillway, and the projected tunnel line. Rock was found along the dam site at depths of from 15 to 20 feet. The formation was rather soft sandstone, suitable for the foundation for the core wall. It would hardly be solid enough, however, for the foundation for a masonry dam.

EARTHEN DAM.

The principal problem here was to determine the height of a dam so that a safe and economical canal location could be made out of the canyon. As at present contemplated, an earthen structure 195 feet high is to be built. The top length of the dam is 2,246 feet. With side slopes of 3 to 1 upper, and 2 to 1 lower, the total contents of the dam will be 3,940,000 cubic yards. The general elevation of the river bottom is 2,685 feet. The spillway will be at 2,865 feet; the top of dam at 2,880 feet. The storage capacity between the 2,855 and 2,880 contours is 450,730 acre-feet.

PUMPING.

On account of the unusual height of this dam, 195 feet, it being 50 feet higher than any existing earth structure, plans have been considered for a lower dam, 150 feet high, and for pumping the remainder of the distance, 45 feet or more. As the principal function of this dam is diversion and not storage, a large percentage of the discharge of the river will be wasted. It has, therefore, been proposed to utilize this waste water by developing hydraulic power for pumping.

Following are the data in relation to this plant: River elevation, 2,685; elevation of top of dam, 2,835; height of dam, 150 feet; elevation of top of spillway, 2,820 feet; freeboard, 15 feet. The minimum lift by pump, 2,820 feet to 2,865 feet, will be 45 feet. Where the natural flow of the river does not supply sufficient water for the canal and for pumping, the supply of the stored water for the upper 20 feet in the reservoir may be drawn on. The maximum lift by pumping would, therefore, be from 2,800 to 2,865, or 65 feet.

The capacity of the reservoir at the 2,820-foot contour is 572,135 acre-feet, and at the 2,800-foot contour, 369,210 acre-feet, the difference being 192,925 acre-feet.

The dam to the 2,835-foot level, with slopes of 3 to 1 on the upper and 2 to 1 on the lower side, would contain 2,343,747 cubic yards.

DIVERSION CANAL.

The elevation at the bottom of the canal at the head will be 2,855; the grade will be 0.00015, or a fall of 0.792 foot to the mile. The dimensions of the canal are: Bottom width, 25 feet; depth of water, 10 feet; side slopes, 1.5 to 1; computed discharge, 1,050 second-feet.

The canal will continue down the left bank of Marias Canyon and run near its top for 9 miles, when it will cross Black Coulee and continue for 8 miles farther, cutting through in this stretch the divide between Black Coulee and Big Sandy drainage. In the first 9-mile stretch there is really only 6 miles of steep sidehill construction. The formation passed through will be largely soft sandstone in horizontal strata, giving a safer location than if the material were of clay subject to sliding when wet.

The first design of the canal provided for a capacity of 2,000 second-feet, but owing to the discovery of Lonesome Lake reservoir this capacity was reduced to 1,050 second-feet. Twenty-two miles from the head of the canal a lateral would be taken off to be used as a feeder for the Lonesome Lake reservoir. From the head of this lateral a high-line canal would be continued at the same elevation and grade as the preceding section. The length of this canal and the area controlled by it are shown in the table on page —.

LONESOME LAKE RESERVOIR.

In T. 29 N., R. 11 and 12 E., there is a natural depression known as Lonesome Lake, which for the past two or three years has been dry. This lake basin was surveyed during 1904 as a reservoir site, and the following table shows its capacities for different elevations.

Capacity of Lonesome Lake reservoir site.

Main reservoir.				Northeast corner additional.			
Contour.	Area.	Capacity of section.	Total capacity.	Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-ft.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-ft.*	*Acre-feet.*
2,745	40	115	115	2,760	112	345	345
2,750	1,460	3,750	3,865	2,765	306	1,045	1,390
2,755	2,594	10,135	14,000	2,770	464	1,925	3,315
2,760	4,280	17,185	31,185	2,775	614	2,695	6,010
2,765	5,831	25,280	56,465	2,780	750	3,410	9,420
2,770	7,697	33,820	90,285				
2,775	10,312	45,020	135,305				
2,780	12,411	56,810	192,115				

In order to create this reservoir, it is necessary to construct an earthen dam at the outlet in the NE. ¼ of sec. 34, T. 29 N., R. 12 E., and also an embankment 24,000 feet in length along the eastern edge of the site. The maximum height of this embankment will be 24 feet. The maximum height of the dam in the outlet will be 49 feet. The dimensions of the dam and embankment are as follows: Elevation of top, 2,785 feet; top width, 12 feet; upper and lower slopes, 2 to 1. The main outlet will be 930 feet long and contain 74,632 cubic yards. At the northeast corner of the reservoir two plans are possible for the embankment. What is known as the "A" line will be the shorter of the two, containing less material; but a greater reservoir capacity will be obtained by the construction of the "B" line. The additional capacity under this line is 9,420 acre-feet, making the total capacity 201,535 acre-feet.

The embankment that is common to both lines will be 13,600 feet long and will contain 98,712 cubic yards. The "A" line embankment will be 6,800 feet long and will contain 191,947 cubic yards, making a total for the main line and "A" line of 290,659 cubic yards. "B" line of embankment will be 10,400 feet long and will contain 248,527 cubic yards; or, combining with the main line, a total of 347,239 cubic yards. The "B" line is thus 3,600 feet longer, and has 56,580 cubic yards more material.

RESERVOIR CANALS.

The discharge from the reservoir will be controlled by gates in an outlet tower. The water will issue at an elevation of 2,750 feet, and continue down the natural channel for 3 miles, or to an elevation of 2,691 feet, when the west and east reservoir canals will be diverted. These canals will be of the same dimensions at the head, as follows: Bottom width, 20 feet; depth of water, 6.2 feet; grade, .0002; discharge, 400 second-feet. The west reservoir canal will be 60 miles long and will control 30,160 acres, and the east canal will be 38 miles long and will serve 33,740 acres.

LOWER YELLOWSTONE PROJECT.[a]

GENERAL STATEMENT.

This project includes about 70,000 acres along the left or west side of Yellowstone River, extending from a point about 20 miles below Glendive to the junction of the Yellowstone and Missouri rivers. The plans for the development of this work contemplate

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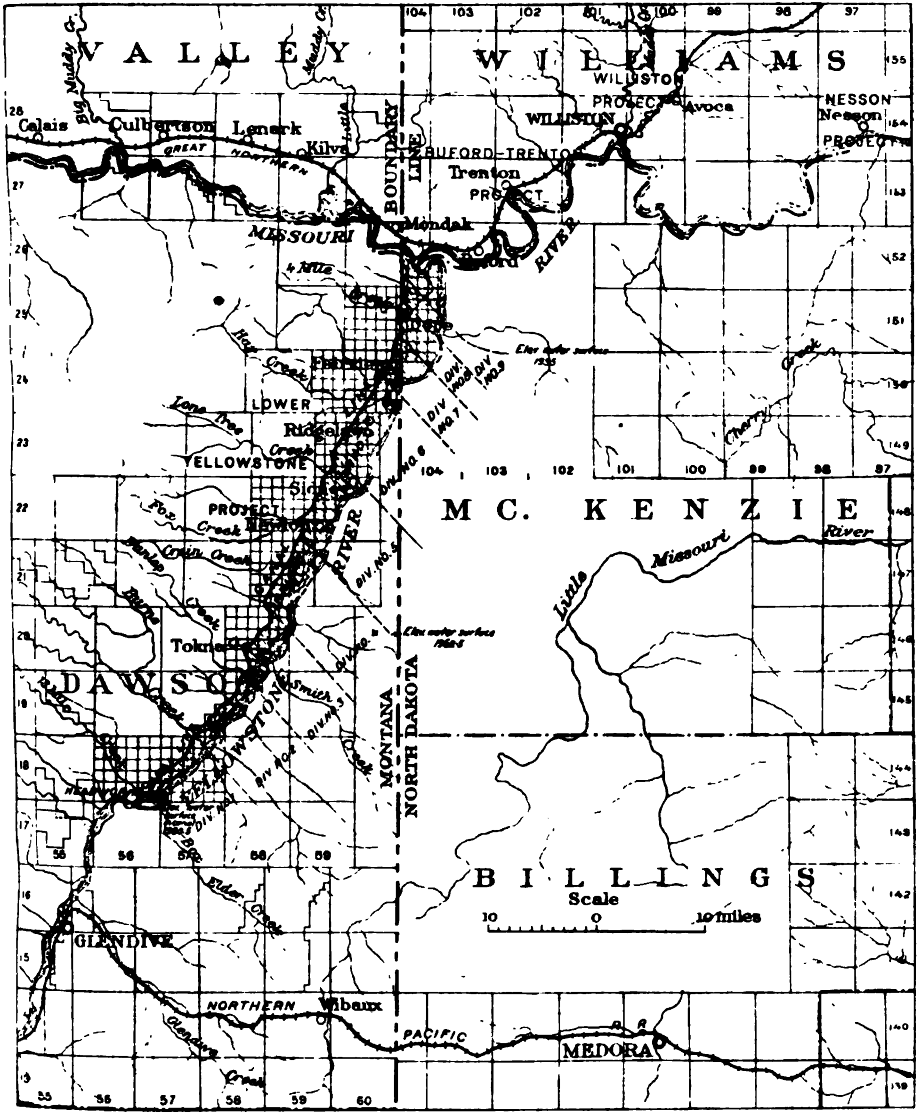
[a] From report by F. E. Weymouth.



GENERAL MAP OF LOWER YELLOWSTONE PROJECT, MONTANA

the construction of a diversion dam across the Yellowstone River and a main canal 67 miles long, with a suitable lateral and distribution system. (See Pl. XXI.)

Preliminary investigations of this project were made during the field season of 1904. The results of these investigations and a general description of the project are described under the heading "Fort Buford project" in the Third Annual Report of the Reclamation Service, second edition, pages 432–439.

The construction work on this project is proceeding rapidly and satisfactorily. Buildings to serve for headquarters have been erected at La Mesa and at the headworks site. The engineering work has been carried forward to keep pace with the requirements and the organization of the Water Users' Association perfected.

The irrigable lands have been mapped on a scale of 1,000 feet to an inch, with 5-foot contour intervals, and have been classified by the engineer of soils preparatory to the subdivision into farm units.

MAIN CANAL AND LATERALS.

During the winter of 1904–5 contract plans for the first 34 miles of main canal were worked up, including the headworks, spillways, sluiceways, conduits, and other structures. (See Pls. XXII–XXV.) These plans were passed upon and approved in March, 1905, by a board of consulting engineers, consisting of Messrs. J. H. Quinton, A. J. Wiley, and H. N. Savage. The work was advertised on April 3, and bids were opened at Glendive, Mont., June 1. Contracts have been awarded as follows: Schedule A, division 1 (about 7½ miles of canal), to The Widell-Finley Company, of Mankato, Minn; schedule A, divisions 2, 3, and 4 (about 26½ miles of canal), to Callahan Bros. and Phelan & Shirley, of Omaha, Nebr.; schedule B, divisions 1, 2, and 3, to Charles Stabern, of Helena, Mont.; and schedule B, division 4, to the Deadwood Construction Company, of Deadwood, S. Dak. These contracts have been executed as follows: The Widell-Finley Company, on August 16, 1905; Callahan Bros. and Phelan & Shirley, on August 17, 1905; Charles Stabern, on August 5, 1905; and Deadwood Construction Company, on August 1, 1905. In each case contract was executed with the lowest bidder.

Bids for main canal, Lower Yellowstone project.

DIVISION 1, SCHEDULE A (EXCAVATION).

Item.	Quantity.	Widell, Finley Co., Mankato, Minn.		Callahan Bros., Phelan & Shirley, Omaha, Nebr.		Griffith & McDermott, Chicago, Ill.		Orman & Crook,[a] Pueblo, Colo.		Cotton Bros. & Co., Oakland, Cal.		Jas. Forrestal & Co., St. Paul, Minn.		C. A. Warren & Co., San Francisco, Cal.		W. J. Bradshaw, Helena, Mont.	
		Unit price.	Amount.	Unit. price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount
Excavation:	*Cu. yards.*																
Class 1	1,077,000	$0.14¼	$153,472.50	$0.14¾	$158,857.50	$0.15⅔	$168,730.00	$0.16	$172,320.00	$0.18⁸⁄₁₀	$202,476.00	$0.23½	$253,095.00	$0.23	$247,710.00	......	....
Class 2	1,000	.28	280.00	.30	300.00	.35	350.00	.35	350.00	.70	700.00	.80	800.00	.46	460.00	......	....
Class 3	1,000	.45	450.00	.30	300.00	.40	400.00	.37	370.00	.70	700.00	1.00	1,000.00	.46	460.00	......	....
Class 4	1,000	.97	970.00	.60	600.00	.75	750.00	.80	800.00	.90	900.00	6.50	6,500.00	1.40	1,400.00	......	....
Wet excavation in canal	20,000	.30	6,000.00	.15	3,000.00	.30	6,000.00	.45	9,000.00	.22½	4,500.00	.70	14,000.00	1.75	35,000.00	......	....
Overhaul	25,000	.01½	375.00	.01	250.00	.01¼	312.50	.01½	375.00	.02½	625.00	.04	1,000.00	.01	250.00	......	....
Terra-cotta pipe:	*Lin. feet.*																
24-inch	120	2.00	240.00	2.80	336.00	2.00	240.00	3.50	420.00	3.50	420.00	4.00	480.00	3.60	432.00	......	....
30-inch	120	3.50	420.00	4.20	504.00	3.40	408.00	5.50	660.00	5.60	672.00	5.00	600.00	4.40	528.00	......	....
36-inch	120	5.50	660.00	7.00	840.00	5.10	612.00	8.00	960.00	7.70	924.00	7.00	840.00	7.00	840.00	......	....
	Cu. yards.																
Puddling	1,000	.50	500.00	.25	250.00	.60	600.00	.40	400.00	1.40	1,400.00	.25	250.00	2.00	2,000.00	......	....
Total	....	......	163,367.50	......	165,237.50	......	178,402.50	......	[a]185,655.00	......	213,317.00	......	278,565.00	......	289,080.00	......	....

DIVISION 2, SCHEDULE A (EXCAVATION).

Excavation:	*Cu. yards.*																
Class 1	1,052,000	$0.18	$189,360.00	$0.14½	$152,540.00	$0.14⅔	$154,293.33	$0.14½	$152,540.00	......	....	$0.22	$231,440.00	......	....	......	....
Class 2	1,300	.30	390.00	.30	390.00	.35	455.00	.35	455.00	......	....	.80	1,040.00	......	....	......	....
Class 3	1,200	.45	540.00	.30	360.00	.40	480.00	.37	444.00	......	....	.80	960.00	......	....	......	....
Class 4	1,000	.97	970.00	.65	650.00	.75	750.00	.80	800.00	......	....	6.00	6,000.00	......	....	......	....

Overhaul	150,000	.01½	2,250.00	.01	1,500.00	.01¼	1,875.00	.01½	2,250.00			.03	4,500.00				
Terra-cotta pipe:	*Lin. feet.*																
24-inch	120	2.00	240.00	2.80	336.00	2.00	240.00	3.70	444.00			4.00	480.00				
30-inch	120	3.50	420.00	4.20	504.00	3.40	408.00	5.75	690.00			5.00	600.00				
36-inch	360	5.25	1,890.00	7.00	2,520.00	5.10	1,836.00	8.30	2,988.00			7.00	2,520.00				
	Cu. yards.																
Puddling	2,000	.50	1,000.00	.50	1,000.00	.60	1,200.00	.40	800.00			.25	500.00				
Total			197,060.00		159,800.00		161,537.33		*a*161,411.00				248,040.00				

DIVISION 3, SCHEDULE A (EXCAVATION).

Excavation:	*Cu. yards.*																
Class 1	1,042,000	$0.18	$187,560.00	$0.12 9/10	$134,418.00	$0.14⅔	$152,826.67	$0.14½	$151,090.00			$0.22	$229,240.00				
Class 2	1,200	.30	360.00	.30	360.00	.35	420.00	.37	444.00			.60	720.00				
Class 3	800	.45	360.00	.30	240.00	.40	320.00	.40	320.00			1.00	800.00				
Class 4	100	.97	97.00	.65	65.00	.75	75.00	.80	80.00			6.50	650.00				
Overhaul	100,000	.01½	1,500.00	.01	1,000.00	.01¼	1,250.00	.01½	1,500.00			.03	3,000.00				
Terra-cotta pipe:	*Lin. feet.*																
24-inch	110	2.00	220.00	2.80	308.00	2.40	264.00	4.25	467.50			4.00	440.00				
30-inch	240	3.50	840.00	4.20	1,008.00	3.80	912.00	6.25	1,500.00			5.00	1,200.00				
36-inch	360	5.25	1,890.00	7.00	2,520.00	5.50	1,980.00	8.75	3,150.00			7.00	2,520.00				
	Cu. yards.																
Puddling	2,000	.50	1,000.00	.50	1,000.00	.60	1,200.00	.40	800.00			.25	500.00				
Total			193,827.00		140,919.00		159,247.67		*a*159,351.50				239,070.00				

a With condition that bidders receive at least two divisions under Schedule A.

Bids for main canal, Lower Yellowstone project—Continued.

DIVISION 4, SCHEDULE A (EXCAVATION).

Item.	Quantity.	Widell, Finley Co., Mankato, Minn.		Callahan Bros., Phelan & Shirley, Omaha, Nebr.		Griffith & McDermott, Chicago, Ill.		Orman & Crook,[a] Pueblo, Colo.		Cotton Bros. & Co., Oakland, Cal.		Jas. Forrestal & Co., St. Paul, Minn.		C. A. Warren & Co., San Francisco, Cal.		W. J. Bradshaw, Helena, Mont.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amonut.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:	*Cu. yards.*																
Class 1	411,000	$0.14	$57,540.00	$0.12	$49,320.00	$0.14⅔	$60,280.00	$0.14	$57,540.00	......	....	$0.14	$57,540.00	......	....	$0.20	$82,200.00
Class 2	800	.28	224.00	.30	240.00	.35	280.00	.32	256.00	......	....	.60	480.00	......	....	.30	240.00
Class 3	1,200	.45	540.00	.30	360.00	.40	480.00	.35	420.00	......	....	.60	720.00	......	....	.35	420.00
Class 4	100	.97	97.00	.65	65.00	.75	75.00	.70	70.00	......	....	6.00	600.00	......	....	1.00	100.00
Overhaul	85,000	.01½	1,275.00	.01	850.00	.01¼	1,062.50	.01½	1,275.00	......	....	.03	2,550.00	......	....	.01½	1,275.00
Terra-cotta pipe.	*Lin. feet.*																
24-inch	240	2.00	480.00	2.80	672.00	2.60	624.00	4.50	1,080.00	......	....	4.00	960.00	......	....	5.40	1,296.00
30-inch	360	3.50	1,260.00	4.20	1,512.00	4.00	1,440.00	6.50	2,340.00	......	....	6.00	2,160.00	......	....	7.68	2,764.80
36-inch	360	5.50	1,980.00	7.00	2,520.00	5.90	2,124.00	9.00	3,240.00	......	....	8.00	2,880.00	......	....	9.50	3,420.00
	Cu. yards.																
Puddling	1,000	.50	500.00	.50	500.00	.60	600.00	.40	400.00	......	....	.25	250.00	......	....	1.00	1,000.00
Total	....	......	63,896.00	......	56,039.00	......	66,965.50	......	[a]66.621.00	......	....	......	68,140.00	......	....	......	92,715.80

DIVISIONS 1, 2, 3, AND 4, SCHEDULE A (EXCAVATION).

Excavation:	*Cu. yards.*																
Class 1	3,582,000	$0.15	$537,300.00									$0.21⅓	$764,160.00	$0.20	$716,400.00		
Class 2	4,300	.28	1,204.00									.75	3,225.00	.45	1,935.00		
Class 3	4,200	.45	1,890.00									.75	3,150.00	.45	1,890.00		
Class 4	2,200	.97	2,134.00									6.25	13,750.00	1.40	3,080.00		
Wet excavation in canal	20,000	.30	6,000.00									.70	14,000.00	1.75	35,000.00		
Overhaul	360.000	.01½	5,400.00									.03	10,800.00	.01	3,600.00		
Terra-cotta pipe:	*Lin. feet.*																
24-inch	600	1.95	1,170.00									4.00	2,400.00	4.00	2,400.00		
30-inch	840	3.45	2,898.00									5.00	4,200.00	5.50	4,620.00		
36-inch	1,200	5.45	6,540.00									7.00	8,400.00	8.00	9,600.00		
	Cu. yards.																
Puddling	6,000	.50	3,000.00									[a].25	1,500.00	2.00	12,000.00		
Total			567,536.00										825,585.00		790,525.00		

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[a] With condition that bidders receive at least two divisions under Schedule A.

Bids for main canal, Lower Yellowstone project—Continued.

DIVISION 1, SCHEDULE B (STRUCTURES).

Item.	Quantity.	Chas. Stabern, Helena, Mont.		Deadwood Construction Co., Deadwood, S. Dak.		Widell-Finley Co., Mankato, Minn.		Jas. Forrestal & Co., St. Paul, Minn.		Cotton Bros. & Co., Oakland, Cal.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:											
Class 1 ... cubic yards..	18,000	$0.24	$4,320.00	$0.25	$4,500.00	$0.30	$5,400.00	$0.40	$7,200.00	$0.46	$8,280.00
Class 2 ... do....	1,500	.34	510.00	.40	600.00	.40	600.00	.80	1,200.00	.82	1,230.00
Class 3 ... do....	1,000	.50	500.00	.45	450.00	.60	600.00	1.00	1,000.00	.96	960.00
Class 4 ... do....	1,300	.60	780.00	.95	1,235.00	1.25	1,625.00	1.50	1,950.00	1.12	1,456.00
Wet excavation at headworks ... do....	3,400	1.25	4,250.00	1.50	5,100.00	1.25	4,250.00	1.00	3,400.00	2.25	7,650.00
Overhaul ... do....	3,000	.01½	45.00	.02	60.00	.02	60.00	.04	120.00	.02½	75.00
Refilling ... do....	300	.60	180.00	.55	165.00	.25	75.00	.30	90.00	.35	105.00
Riprap ... do....	800	1.99	1,592.00	2.00	1,600.00	2.00	1,600.00	2.50	2,000.00	2.36	1,888.00
Concrete:											
Class 1 ... do....	210	5.00	1,050.00	5.75	1,207.50	2.75	577.50	10.00	2,100.00	8.40	1,764.00
Class 2 ... do....	4,850	4.25	20,612.50	4.75	23,037.50	2.60	12,610.00	8.00	38,800.00	8.05	39,042.50
Placing gates, headworks ... pounds..	100,000	.00¾	750.00	.00¾	750.00	.07	7,000.00	.01	1,000.00	.01$\frac{3}{10}$	1,300.00
Placing steel for concrete reenforcement ... do....	91,800	.00$\frac{4}{10}$	367.20	.00¾	688.50	.04	3,672.00	.01	918.00	.00$\frac{7}{10}$	642.60
Piles:											
Delivered ... linear feet..	7,900	.20	1,580.00	.30	2,370.00	.30	2,370.00	.18	1,422.00	.60	4,740.00
Driven ... do....	7,500	.20	1,500.00	.25	1,875.00	.21	1,575.00	.20	1,500.00	.17	1,275.00
Sheet piles:											
Delivered ... feet B. M..	25,000	26.50	622.50	38.00	950.00	21.50	537.50	30.00	750.00	56.25	1,406.25
Driven—											
Class A ... linear feet	5,000	.13½	675.00	.25	1,250.00	2.00	10,000.00	.10	500.00	.35	1,750.00
Class B ... do....	800	.13½	108.00	.20	160.00	1.25	1,000.00	.07	56.00	.35	280.00
Lumber ... feet B. M..	26,000	32.00	832.00	40.00	1,040.00	22.00	572.00	30.00	780.00	59.50	1,547.00
Steel ... pounds..	7,800	.06	468.00	.07	546.00	.06	468.00	.04	312.00	.14	1,092.00

Cast iron....do....	1,000	.05	50.00	.06	60.00	.50½	55.00	.04	40.00	.12	120.00
Terra-cotta pipe, 8-inch....linear feet..	110	1.00	110.00	.50	55.00	.50	55.00	.50	55.00	1.00	110.00
Total....	....	....	40,942.20	....	47,699.50	....	54,702.00	....	65,193.00	....	76,713.35

DIVISION 2, SCHEDULE B (STRUCTURES).

Excavation:											
Class 1....cubic yards..	4,000	$0.24	$960.00	$0.25	$1,000.00	$0.30	$1,200.00	$0.30	$1,200.00	....	....
Class 2....do....	200	.34	68.00	.40	80.00	.40	80.00	.80	160.00	....	....
Class 3....do....	300	.50	150.00	.50	150.00	.60	180.00	1.00	300.00	....	....
Class 4....do....	10	.60	6.00	1.50	15.00	1.25	12.50	1.50	15.00	....	....
Overhaul....do....	10,000	.01½	150.00	.02	200.00	.02	200.00	.03	300.00	....	....
Refilling....do....	2,700	.60	1,620.00	.55	1,485.00	.25	675.00	.20	540.00	....	....
Riprap....do....	8,600	1.99	17,114.00	2.00	17,200.00	2.00	17,200.00	5.00	43,000.00	....	....
Concrete:											
Class 1....do....	2,500	5.00	12,500.00	5.75	14,375.00	2.90	7,250.00	10.00	25,000.00	....	....
Class 2....do....	100	4.25	425.00	5.25	525.00	2.75	275.00	8.00	800.00	....	....
Placing steel for concrete reenforcement....pounds..	207,700	.00$\frac{4}{10}$	830.80	.00$\frac{8}{10}$	1,661.60	.04½	9,346.50	.01½	3,115.50	....	....
Sheet piles:											
Delivered....feet B.M..	68,800	26.50	1,823.20	40.00	2,752.00	22.00	1,513.60	30.00	2,064.00	....	....
Driven, Class B....linear feet..	12,400	.13½	1,674.00	.15	1,860.00	1.25	15,500.00	.07	868.00	....	....
Lumber....feet B.M..	16,000	32.00	512.00	40.00	640.00	22.50	360.00	30.00	480.00	....	....
Steel....pounds..	16,500	.06	990.00	.08	1,320.00	:06¼	1,031.25	.04	660.00	....	....
Cast iron....do....	100	.05	5.00	.07	7.00	.05¾	5.75	.04	4.00	....	....
Total....	....	....	38,828.00	....	43,270.60	....	54,829.60	....	78,506.50	....	....

Bids for main canal, Lower Yellowstone project—Continued.

DIVISION 3, SCHEDULE B (STRUCTURES).

Item.	Quantity.	Chas. Stabern, Helena, Mont.		Deadwood Construction Co., Deadwood, S. Dak.		Widell-Finley Co., Mankato, Minn.		Jas. Forrestal & Co., St. Paul, Minn.		Cotton Bros. & Co., Oakland, Cal.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:											
Class 1 ....cubic yards..	3,500	$0.24	$840.00	$0.25	$875.00	$0.30	$1,050.00	$0.30	$1,050.00	....	....
Class 2 ....do....	300	.34	102.00	.40	120.00	.40	120.00	.80	240.00	....	....
Class 3 ....do....	200	.50	100.00	.50	100.00	.60	120.00	1.00	200.00	....	....
Class 4 ....do....	10	.60	6.00	1.50	15.00	1.25	12.50	2.00	20.00	....	....
Overhaul ....do....	10,000	.01½	150.00	.02	200.00	.02	200.00	.03	300.00	....	....
Refilling ....do....	2,000	.60	1,200.00	.55	1,100.00	.25	500.00	.20	400.00	....	....
Riprap ....do....	4,300	1.99	8,557.00	2.00	8,600.00	2.00	8,600.00	4.50	19,350.00	....	....
Concrete:											
Class 1 ....do....	1,940	5.00	9,700.00	6.00	11,640.00	2.90	5,626.00	10.00	19,400.00	....	....
Class 2 ....do....	150	4.25	637.50	5.50	825.00	2.75	412.50	8.00	1,200.00	....	....
Placing steel for concrete reenforcement ....pounds..	173,300	.00$\frac{4}{10}$	693.20	.01	1,733.00	.04½	7,798.50	.01½	2,599.50	....	....
Sheet piles:											
Delivered ....feet B.M..	36,200	26.50	959.30	43.00	1,556.60	22.00	796.40	30.00	1,086.00	....	....
Driven, Class B ....linear feet..	6,890	.13½	930.15	.15	1,033.50	1.25	8,612.50	.07	482.30	....	....
Lumber ....feet B.M..	5,500	32.00	176.00	43.00	236.50	22.50	123.75	30.00	165.00	....	....
Steel ....pounds..	7,500	.06	450.00	.08	600.00	.06¼	468.75	.04	300.00	....	....
Cast iron ....do....	100	.05	5.00	.07	7.00	.05¾	5.75	.04	4.00	....	....
Total	....	....	24,506.15	....	28,641.60	....	34,446.65	....	46,796.80	....	....

DIVISION 4, SCHEDULE B (STRUCTURES).

Excavation:										
Class 1....cubic yards..	4,500	......	......	$0.25	$1,125.00	$0.30	$1,350.00	$0.30	$1,350.00	......	......
Class 2....do....	200	......	......	.40	80.00	.40	80.00	.60	120.00	......	......
Class 3....do....	300	......	......	.50	150.00	.60	180.00	.60	180.00	......	......
Class 4....do....	10	......	......	1.50	15.00	1.25	12.50	1.00	10.00	......	......
Overhaul....do....	10,000	......	......	.02	200.00	.02	200.00	.03	300.00	......	......
Refilling....do....	2,000	......	......	.55	1,100.00	.25	500.00	.20	400.00	......	......
Riprap....do....	4,510	......	......	2.00	9,020.00	2.25	10,147.50	4.50	20,295.00	......	......
Concrete:											
Class 1....do....	1,690	......	......	6.25	10,562.50	2.75	4,647.50	10.00	16,900.00	......	......
Class 2....do....	110	......	......	5.75	632.50	2.60	286.00	8.00	880.00	......	......
Placing steel for concrete reenforcement....pounds..	167,200	......	......	.01	1,672.00	.04½	7,524.00	.02	3,344.00	......	......
Sheet piles:											
Delivered....feet B.M..	38,800	......	......	45.00	1,746.00	22.00	853.60	38.00	1,474.40	......	......
Driven, Class B....linear feet..	6,000	......	......	.15	900.00	1.25	7,500.00	.07	420.00	......	......
Lumber....feet B.M..	6,500	......	......	45.00	292.50	22.50	146.25	38.00	247.00	......	......
Steel....pounds..	8,000	......	......	.08	640.00	.06¼	500.00	.05	400.00	......	......
Cast iron....do....	100	......	......	.07	7.00	.05¾	5.75	.05	5.00	......	......
Total....	......	......	......	......	28,142.50	......	33,933.10	......	46,325.40	......	......

Bids for main canal, Lower Yellowstone project—Continued.

DIVISIONS 1, 2, 3, AND 4, SCHEDULE B (ALL STRUCTURES).

Item.	Quantity.	Griffith & McDermott, Chicago, Ill.		Duncan McKenzie, Great Falls, Mont.		Widell-Finley Co., Mankato, Minn.		Jas. Forrestal & Co., St. Paul, Minn.		Cotton Bros. & Co. Oakland, Cal.		Orman & Crook, Pueblo, Colo.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:													
Class 1..................cubic yards..	30,000	$0.20	$6,000.00	$0.40	$12,000.00	$0.28	$8,400.00	$0.28	$8,400.00	$0.44	$13,200.00	$0.23	$6,900.00
Class 2..........................do....	2,200	.35	770.00	.60	1,320.00	.40	880.00	.75	1,650.00	.60	1,320.00	.45	990.00
Class 3..........................do....	1,800	.40	720.00	.45	810.00	.60	1,080.00	.75	1,350.00	.62	1,116.00	.50	900.00
Class 4..........................do....	1,330	1.00	1,330.00	1.50	1,995.00	1.25	1,662.50	1.25	1,662.50	1.00	1,330.00	.90	1,197.00
Wet excavation headworks.........do....	3,400	.60	2,040.00	3.50	11,900.00	1.25	4,250.00	1.00	3,400.00	2.25	7,650.00	1.00	3,400.00
Overhaul.........................do....	33,000	.02	660.00	.01	330.00	.02	660.00	.03	990.00	.02¼	742.50	.01½	495.00
Refilling........................do....	7,000	.18	1,260.00	.37	2,590.00	.25	1,750.00	.20	1,400.00	.25	1,750.00	.50	3,500.00
Riprap...........................do....	18,210	2.00	36,420.00	a2.50	45,525.00	2.00	36,420.00	4.65	84,676.50	2.40	43,704.00	3.00	54,630.00
Concrete:													
Class 1..........................do....	6,340	6.10	38,674.00	6.25	39,625.00	2.70	17,118.00	10.00	63,400.00	6.90	43,746.00	6.90	43,746.00
Class 2..........................do....	5,210	5.60	29,176.00	5.75	29,957.50	2.55	13,285.50	8.00	41,680.00	6.00	31,260.00	5.50	28,655.00
Placing steel for concrete reinforcement...........................pounds..	640,000	.01½	9,600.00	.01	6,400.00	.04	25,600.00	.01½	9,600.00	.00½	3,200.00	.01¾	11,200.00
Placing gates headworks..........do....	100,000	.01¼	1,250.00	.00¾	750.00	.07	7,000.00	.01	1,000.00	.01 3/10	1,300.00	.01¾	1,750.00
Piles:													
Delivered...............linear feet..	7,900	.37	2,923.00	.30	2,370.00	.30	2,370.00	.18	1,422.00	.60	4,740.00	.30	2,370.00
Driven..........................do....	7,500	.35	2,625.00	.40	3,000.00	.21	1,575.00	.20	1,500.00	.17	1,275.00	.45	3,375.00
Sheet piles:													
Delivered.................feet B. M..	163,800	40.00	6,552.00	38.00	6,224.40	21.75	3,562.65	32.00	5,241.60	58.80	9,631.44	37.25	6,101.55
Driven—													
Class A..............linear feet .	5,000	.20	1,000.00	.35	1,750.00	2.00	10,000.00	.10	500.00	.26	1,300.00	.30	1,500.00
Class B.....................do....	26,090	.15	3,913.50	.35	9,131.50	1.00	26,090.00	.07	1,826.30	.22	5,739.80	.30	7,827.00
Lumber........................feet B. M..	54,000	50.00	2,700.00	40.00	2,160.00	22.25	1,201.50	32.00	1,728.00	80.00	4,320.00	43.80	2,365.20
Steel...........................pounds..	39,800	.05½	2,189.00	.06½	2,587.00	.06	2,388.00	.04	1,592.00	.09	3,582.00	.09	3,582.00

Cast iron.........................do....	1,300	.05½	71.50	.06	78.00	.05½	71.50	.04	52.00	.15	195.00	.07	91.00
Terra-cotta pipe, 8-inch......linear feet..	110	.40	44.00	.50	55.00	.45	49.50	.50	55.00	1.00	110.00	.50	55.00
Total..............................	....	....	149,918.00	....	180,558.40	....	a165,414.15	....	233,125.90	....	181,211.74	....	184,629.75

DIVISIONS 1, 2, 3, AND 4, SCHEDULES A AND B (ALL EXCAVATION AND ALL STRUCTURES).

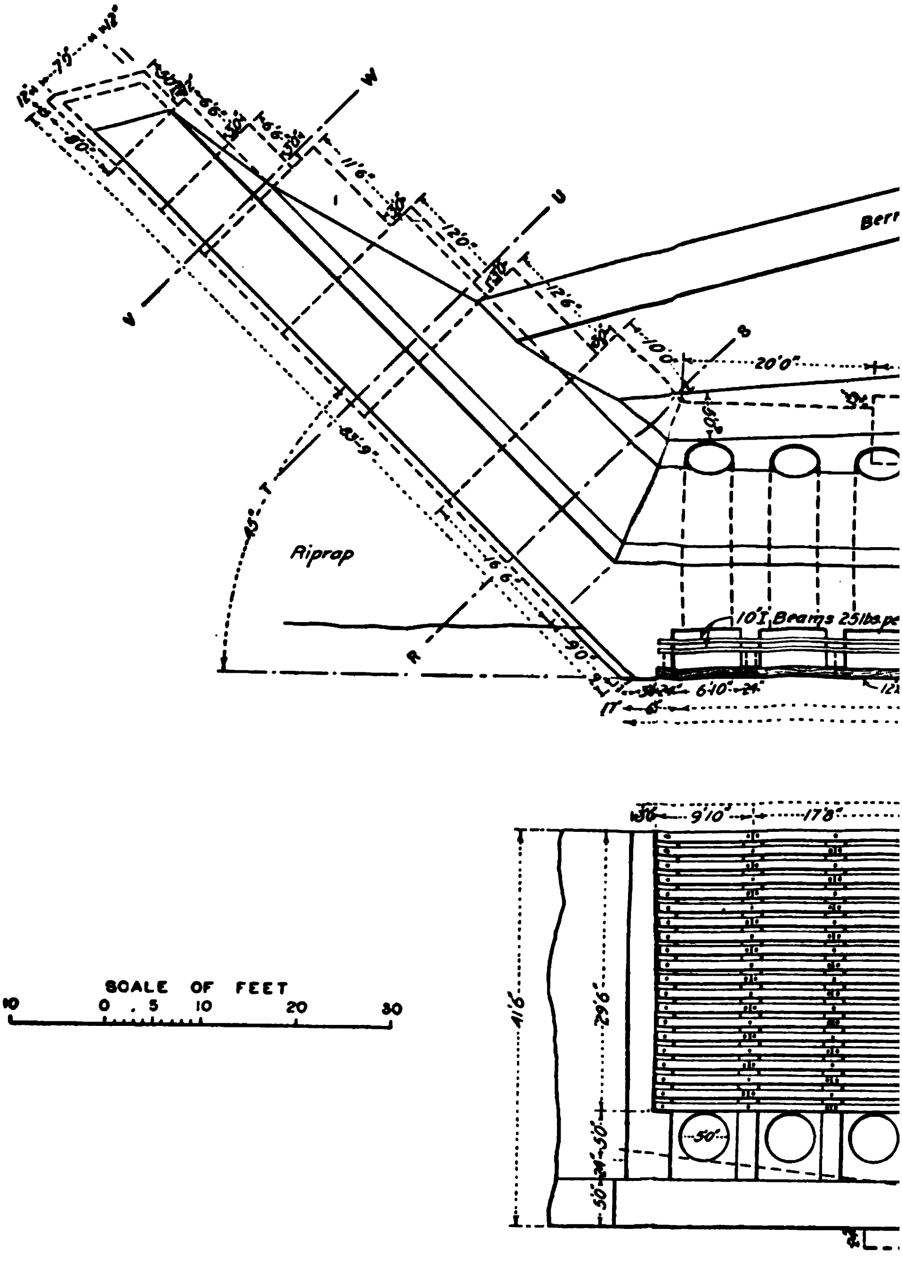
Item.	Quantity.	Foley & Larson, St. Paul, Minn.		C. A. Warren & Co., San Francisco, Cal.		Widell-Finley Co., Mankato, Minn.		Jas. Forrestal & Co., St. Paul, Minn.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:									
Class 1..........cubic yards..	3,612,000	$0.19	$686,280.00	$0.20	$722,400.00	$0.14	$505,680.00	$0.21⅓	$770,560.00
Class 2..........do....	6,500	.30	1,950.00	.45	2,925.00	.28	1,820.00	.75	4,875.00
Class 3..........do....	6,000	.35	2,100.00	.45	2,700.00	.45	2,700.00	.75	4,500.00
Class 4..........do....	3,530	.75	2,647.50	1.40	4,942.00	.97	3,424.10	6.25	22,062.50
Wet excavation:									
Headworks..........do....	3,400	1.25	4,250.00	2.00	6,800.00	1.25	4,250.00	1.00	3,400.00
Canal..........do....	20,000	.65	13,000.00	1.75	35,000.00	.30	6,000.00	.70	14,000.00
Overhaul..........do....	393,000	.01	3,930.00	.01	3,930.00	.01½	5,895.00	.03	11,790.00
Refilling..........do....	7,000	.50	3,500.00	.40	2,800.00	.25	1,750.00	.20	1,400.00
Puddling..........do....	6,000	.65	3,900.00	2.00	12,000.00	.50	3,000.00	.25	1,500.00
Riprap..........do....	18,210	2.25	40,972.50	2.50	45,525.00	2.00	36,420.00	4.65	84,676.50
Concrete:									
Class 1..........do....	6,340	12.00	76,080.00	10.50	66,570.00	2.70	17,118.00	10.00	63,400.00
Class 2..........do....	5,210	6.50	33,865.00	8.50	44,285.00	2.55	13,285.50	8.00	41,680.00
Placing steel for concrete reinforcement..........pounds..	640,000	.00$\frac{7}{10}$	4,480.00	.01¾	11,200.00	.04	25,600.00	.01½	9,600.00
Placing gates headworks..........do....	100,000	.01¼	1,250.00	.02	2,000.00	.07	7,000.00	.01	1,000.00
Piles:									
Delivered..........linear feet..	7,900	.22	1,738.00	.28	2,212.00	.30	2,370.00	.18	1,422.00
Driven..........do....	7,500	.20	1,500.00	.40	3,000.00	.21	1,575.00	.20	1,500.00

a Riprap to be allowed 1½ miles free haul, 50 cents per cubic yard per mile overhaul.

Bids for main canal, Lower Yellowstone project—Continued.

DIVISIONS 1, 2, 3, AND 4, SCHEDULES A AND B (ALL EXCAVATIONS AND ALL STRUCTURES)—Continued.

Item.	Quantity.	Foley & Larson, St. Paul, Minn.		C. A. Warren & Co., San Francisco, Cal.		Widell-Finley Co., Mankato, Minn.		Jas. Forrestal & Co., St. Paul, Minn.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Sheet piles:									
Delivered........feet B. M..	163,800	$30.00	$4,914.00	$43.00	$7,043.40	$21.75	$3,562.65	$32.00	$5,241.60
Driven—									
Class A........linear feet..	5,000	.15	750.00	.40	2,000.00	2.00	10,000.00	.10	500.00
Class B........do....	26,090	.15	3,913.50	.60	15,654.00	1.00	26,090.00	.07	1,826.30
Lumber........feet B. M..	54,000	35.00	1,890.00	45.00	2,430.00	22.25	1,201.50	32.00	1,728.00
Steel........pounds..	39,800	.08½	3,383.00	.10	3,980.00	.06	2,388.00	.04	1,592.00
Cast iron........do....	1,300	.07½	97.50	.09	117.00	.05½	71.50	.04	52.00
Terra-cotta pipe:									
8-inch........linear feet..	110	.35	38.50	.50	55.00	.45	49.50	.50	55.00
24-inch........do....	600	2.50	1,500.00	4.00	2,400.00	1.95	1,170.00	4.00	2,400.00
30-inch........do....	840	3.95	3,318.00	5.50	4,620.00	3.45	2,898.00	5.00	4,200.00
36-inch........do....	1,200	5.85	7,020.00	8.00	9,600.00	5.45	6,540.00	7.00	8,400.00
Total........	....	....	908,267.50	....	1.016,188.40	....	691,858.75	....	1,063,360.90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Bids were opened November 15 for earthwork on the remainder of the main canal and for 74 miles of laterals.

Bids for main canal and lateral system, Lower Yellowstone project, Montana-North Dakota.

DIVISION NO. 5.

Kind of work.	Quantity, in cubic yards.	Widell-Finley Co., Mankato, Minn.		Nels L. Olsen, Butte, Mont.		Lamb & Frye, Glendive, Mont.		Nohle & Mann, Buford, N. Dak.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:									
Class 1	602,000	$0.169	$101,738.00	$0.175	$105,350.00				
Class 2	120,000	.30	36,000.00	.33	39,600.00				
Class 3	100	.50	50.00	.50	50.00				
Class 4	10	1.50	15.00	2.00	20.00				
Overhaul	140,000	.015	2,100.00	.015	2,100.00				
Puddling	3,000	.50	1,500.00	.75	2,250.00				
Total			141,403.00		149,370.00				

DIVISION NO. 6.

Kind of work.	Quantity, in cubic yards.	Widell-Finley Co. Unit price.	Amount.	Nels L. Olsen Unit price.	Amount.	Lamb & Frye Unit price.	Amount.	Nohle & Mann Unit price.	Amount.
Excavation:									
Class 1	272,000	$0.168	$45,696.00	$0.149	$40,528.00				
Class 2	100	.30	30.00	.50	50.00				
Class 3	100	.50	50.00	.50	50.00				
Class 4	10	1.50	15.00	2.00	20.00				
Overhaul	75,000	.015	1,125.00	.015	1,125.00				
Puddling	2,000	.50	1,000.00	.75	1,500.00				
Total			47,916.00		43,273.00				

DIVISION NO. 7.

Kind of work.	Quantity, in cubic yards.	Widell-Finley Co. Unit price.	Amount.	Nels L. Olsen Unit price.	Amount.	Lamb & Frye Unit price.	Amount.	Nohle & Mann Unit price.	Amount.
Excavation:									
Class 1	44,600	$0.165	$7,359.00						
Class 2	200	.30	60.00						
Class 3	200	.50	100.00						
Class 4	10	1.50	15.00						
Overhaul	1,000	.015	15.00						
Puddling	200	.50	100.00						
Total			[a] 7,649.00						

DIVISION NO. 8.

Kind of work.	Quantity, in cubic yards.	Widell-Finley Co. Unit price.	Amount.	Nels L. Olsen Unit price.	Amount.	Lamb & Frye Unit price.	Amount.	Nohle & Mann Unit price.	Amount.
Excavation:									
Class 1	38,000	$0.162	$6,156.00			$0.12	$4,560.00		
Class 2	1,000	.30	300.00			.22	220.00		
Class 3	1,000	.50	500.00			.38	380.00		
Class 4	20	1.50	30.00			1.55	31.00		
Overhaul	1,500	.015	22.50			.015	22.50		
Puddling	200	.50	100.00			1.13	226.00		
Total			[a] 7,108.50				5,439.50		

[a] Conditioned upon the award of Divisions 5 and 6.

Bids for main canal and lateral system, Lower Yellowstone project, Montana-North Dakota—Continued.

DIVISION NO. 9.

Kind of work.	Quantity, in cubic yards.	Widell-Finley Co., Mankato, Minn.		Nels L. Olsen, Butte, Mont.		Lamb & Frye, Glendive, Mont.		Nohle & Mann, Buford, N. Dak.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:									
Class 1	30,000	$0.16	$4,800.00						
Class 2	2,500	.30	750.00						
Class 3	2,500	.50	1,250.00						
Class 4	50	1.50	75.00						
Overhaul	2,000	.015	30.00						
Puddling	200	.50	100.00						
Total			[a] 7,005.00						

LATERALS A AND B.

Kind of work.	Quantity, in cubic yards.	Widell-Finley Co., Mankato, Minn.		Nels L. Olsen, Butte, Mont.		Lamb & Frye, Glendive, Mont.		Nohle & Mann, Buford, N. Dak.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:									
Class 1	23,300	$0.16	$3,728.00						
Class 2	100	.30	30.00						
Class 3	100	.50	50.00						
Class 4	10	1.50	15.00						
Overhaul	500	.015	7.50						
Puddling	100	.50	50.00						
Total			[a] 3,880.50						

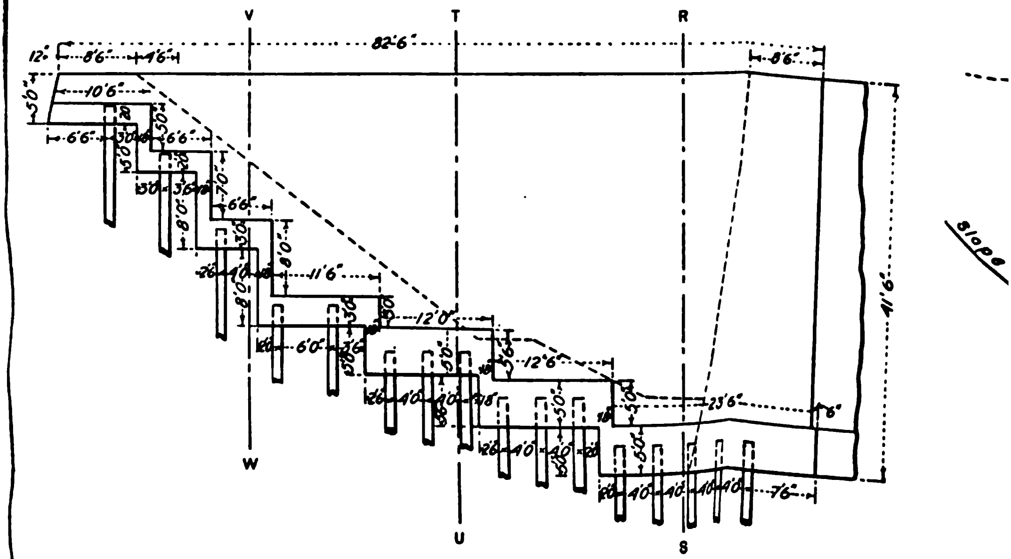
LATERAL C.

Kind of work.	Quantity, in cubic yards.	Widell-Finley Co., Mankato, Minn.		Nels L. Olsen, Butte, Mont.		Lamb & Frye, Glendive, Mont.		Nohle & Mann, Buford, N. Dak.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:									
Class 1	27,800	$0.16	$4,448.00						
Class 2	100	.30	30.00						
Class 3	100	.50	50.00						
Class 4	10	1.50	15.00						
Overhaul	1,000	.015	15.00						
Puddling	200	.50	100.00						
Total			[a] 4,658.00						

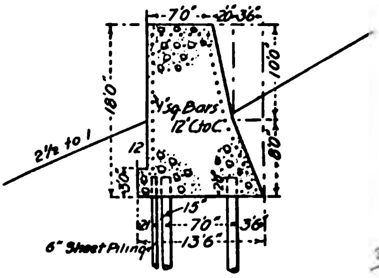
LATERALS D AND E.

Kind of work.	Quantity, in cubic yards.	Widell-Finley Co., Mankato, Minn.		Nels L. Olsen, Butte, Mont.		Lamb & Frye, Glendive, Mont.		Nohle & Mann, Buford, N. Dak.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:									
Class 1	46,800	$0.16	$7,488.00						
Class 2	100	.30	30.00						
Class 3	100	.50	50.00						
Class 4	10	1.50	15.00						
Overhaul	2,000	.015	30.00						
Puddling	200	.50	100.00						
Total			[a] 7,713.00						

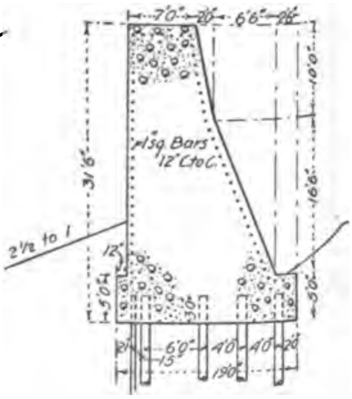
[a] Conditional upon the award of Divisions 5 and 6.



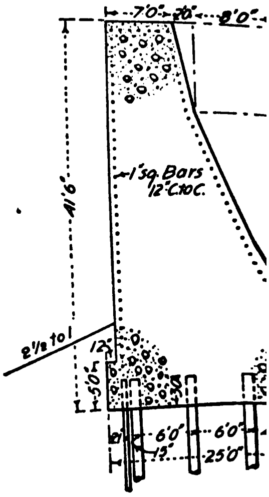
ELEVATION OF WEST WING WALL



SECTION V–W



SECTION T–U



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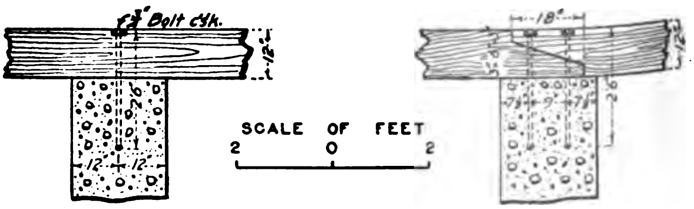

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ds for main canal and lateral system, Lower Yellowstone project, Montana-North Dakota—Continued.

LATERAL F.

Kind of work.	Quantity, in cubic yards.	Widell-Finley Co., Mankato, Minn.		Nels L. Olsen, Butte, Mont.		Lamb & Frye, Glendive, Mont.		Nohle & Mann, Buford, N. Dak.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
xcavation:									
Class 1	93,600	$0.16	$14,976.00			$0.13	$12,168.00		
Class 2	200	.30	60.00			.20	40.00		
Class 3	200	.50	100.00			.35	70.00		
Class 4	10	1.50	15.00			1.60	16.00		
Overhaul	4,000	.015	60.00			.015	60.00		
Puddling	300	.50	150.00			1.15	345.00		
Total			a 15,361.00				12,699.00		

LATERALS Fa AND G.

Excavation:									
Class 1	48,300	$0.16	$7,728.00						
Class 2	100	.30	30.00						
Class 3	100	.50	50.00						
Class 4	10	1.50	15.00						
Overhaul	1,000	.015	15.00						
Puddling	200	.50	100.00						
Total			a 7,938.00						

LATERALS I, J, Ja, AND Jb.

Excavation:									
Class 1	32,300	$0.16	$5,168.00						
Class 2	100	.30	30.00						
Class 3	100	.50	50.00						
Class 4	10	1.50	15.00						
Overhaul	1,000	.015	15.00						
Puddling	200	.50	100.00						
Total			a 5,378.00						

LATERAL K.

Excavation:									
Class 1	57,100	$0.16	$9,136.00						
Class 2	200	.30	60.00						
Class 3	200	.50	100.00						
Class 4	10	1.50	15.00						
Overhaul	1,500	.015	22.50						
Puddling	200	.50	100.00						
Total			a 9,433.50						

Bids for main canal and lateral system, Lower Yellowstone project, Montana-North Dakota—Continued.

LATERAL L.

Kind of work.	Quantity, in cubic yards.	Widell-Finley Co., Mankato, Minn.		Nels L. Olsen, Butte, Mont.		Lamb & Frye, Glendive, Mont.		Nohle & Ma Buford, N. Da	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amou
Excavation:									
Class 1	29,800	$0.16	$4,768.00						
Class 2	100	.30	30.00						
Class 3	100	.50	50.00						
Class 4	10	1.50	15.00						
Overhaul	1,000	.015	15.00						
Puddling	200	.50	100.00						
Total			[a] 4,978.00						

LATERAL M.

Excavation:									
Class 1	28,800	$0.16	$4,608.00						
Class 2	100	.30	30.00						
Class 3	100	.50	50.00						
Class 4	10	1.50	15.00						
Overhaul	1,000	.015	15.00						
Puddling	200	.50	100.00						
Total			[a] 4,818.00						

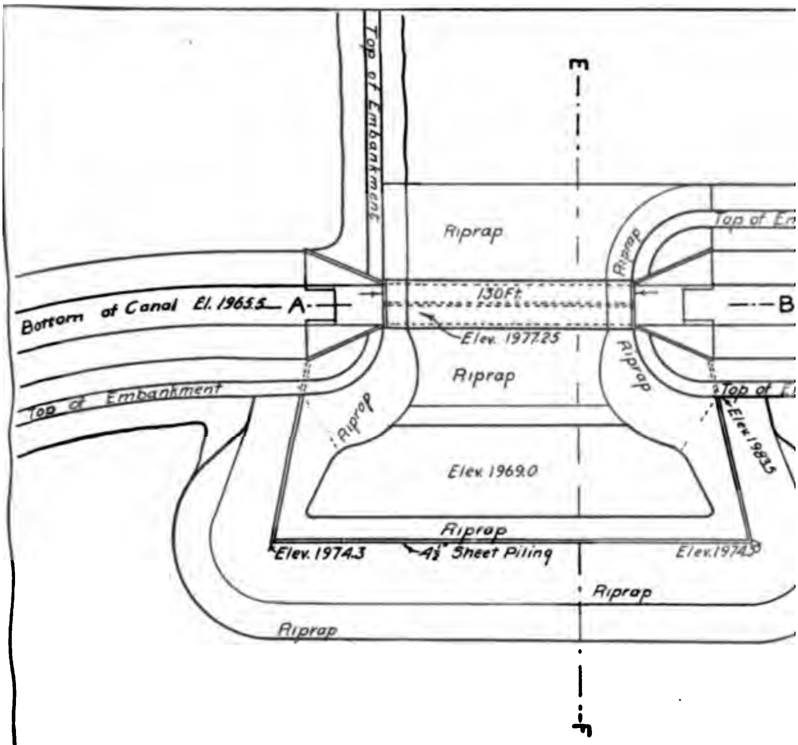
LATERAL N.

Excavation:									
Class 1	36,800	$0.16	$5,888.00					$0.15	$5,520.00
Class 2	100	.30	30.00					.25	25.00
Class 3	100	.50	50.00					.50	50.00
Class 4	10	1.50	15.00					1.00	10.00
Overhaul	1,500	.015	22.50					.015	22.50
Puddling	200	.50	100.00					.50	100.00
Total			[a] 6,105.50						5,727.50

LATERALS O AND P.

Excavation:									
Class 1	45,100	$0.16	$7,216.00			$0.128	$5,772.80	$0.16	$7,216.00
Class 2	200	.30	60.00			.20	40.00	.25	50.00
Class 3	200	.50	100.00			.38	76.00	.80	160.00
Class 4	10	1.50	15.00			1.60	16.00	1.00	10.00
Overhaul	1,500	.015	22.50			.015	22.50	.015	22.50
Puddling	200	.50	100.00			1.55	310.00	.50	100.00
Total			[a] 7,513.50				6,237.30		7,558.50

[a] Conditional upon the award of Divisions 5 and 6.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Riprap
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B
Top of Embankment
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Elev. 1969.0
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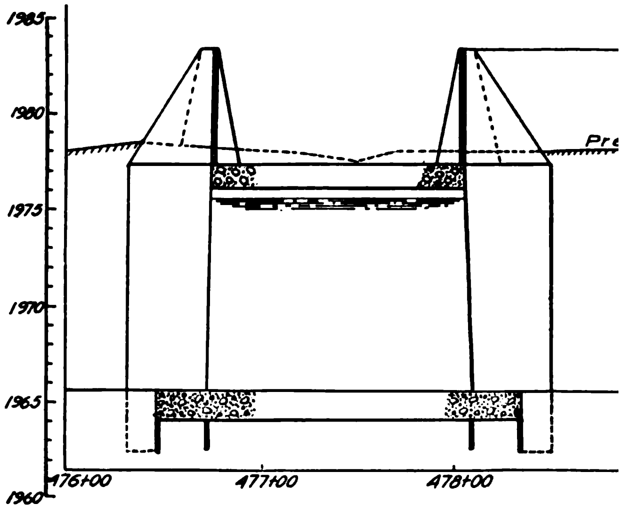
Elev. 1974.3
Elev. 1983.5
Riprap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PROFILE

TELEPHONE LINE.

On April 27, 1905, bids were asked for 70 miles of telephone line for this project, and bids were opened on June 1. Elmer A. Hess, of Lyons, Iowa, being the lowest bidder, contract was entered into with him on August 16.

Schedule of bids for telephone line, Lower Yellowstone project.

Bidder's name.	Section 1 (35 miles).		Section 2 (35 miles).		Section 3.	Section 4.	Total.
	Price per mile.	Amount.	Price per mile.	Amount.	Amount.	Amount.	
Elmer A. Hess, Lyons, Iowa..	$217.08	$7,597.80	$207.19	$7,251.65	$45.00	$45.00	$14,939.45
Wm. F. Jordan, Glendive, Mont	242.00	8,470.00	239.00	8,365.00	72.00	79.00	16,986.00
Frank C. Hughes, Glendive, Mont	249.00	8,715.00	257.00	8,995.00	60.00	70.00	17,840.00
W. H. Crumb & Co., Chicago, Ill	264.50	9,257.50	264.50	9,257.50	50.00	50.00	18,615.00
Burrell Construction Co., Portland, Oreg	335.00	11,725.00	335.00	11,725.00	140.00	120.00	23,710.00

Bidder's name.	Commencement and completion of work.					
	Sections 1 and 3.		Sections 2 and 4.		Sections 1, 2, 3, and 4.	
	Begin within—	Complete within—	Begin within—	Complete within—	Begin within—	Complete within—
Elmer A. Hess, Lyons, Iowa ..	15 days...	50 days...	30 days...	90 days...	15 days...	90 days.
Wm. F. Jordan, Glendive, Mont	7 days....	65 days...	7 days....	65 days...	7 days....	65 days.
Frank C. Hughes, Glendive, Mont.	30 days...	110 days ..	30 days...	110 days ..	30 days...	110 days.
W. H. Crumb & Co., Chicago, Ill.	30 days...	90 days...	30 days...	90 days...	30 days...	120 days.
Burrell Construction Co., Portland, Oreg.	30 days...	Sept. 1....	30 days...	Oct. 1.....	15 days...	Oct. 1.

TELEPHONES TO BE USED.

Elmer A. Hess.	Wm. F. Jordan.	Frank C. Hughes.	W. H. Crumb & Co.	Burrell Construction Co.
Kellogg Switchboard and Supply Co.'s telephones.	Not stated ...	Not stated ...	Kellogg Switchboard and Supply Co.'s, Stromberg-Carlson Telephone Manufacturing Co.'s, or American Electric Telephone Co.'s telephones.	Stromberg-Carlson Telephone Manufacturing Co.'s, or Kellogg Switchboard and Supply Co.'s telephones.

CEMENT.

On July 31 bids were received for furnishing 12,000 to 16,000 barrels of cement to used on construction work. The lowest bidder was the Illinois Steel Company, wi which contract was entered into on August 16, 1905. The following is an abstract of th bids received:

Bids for cement, Lower Yellowstone project.

Name of bidder.	Address.	Price per barrel.		Total.	
		At works.	At Glendive.	At works.	At Glendive.
Illinois Steel Co	1057 The Rookery, Chicago, Ill.	$1.00	$2.82	$12,000.00	$33,840.
Alpha Portland Cement Co.	410 Pioneer Press Building, St. Paul, Minn.	1.37	[a] 3.29	16,400.00	39,480.00
Atlas Portland Cement Co. [b]	30 Broad street, New York, N. Y.	....	2.97	....	35,640.0

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[a] An interlineation states that the price includes 40 cents per barrel for sacks, and that this amount will be refunded on return of sacks in good condition to Duluth, Minn., freight prepaid, and that th delivered price is based on regular tariff rates at 40 cents per 100 pounds.

[b] Letter accompanying bid states that shipment can be made only during period of open navigatio on Lakes; also that inspection of manufacture and daily laboratory analysis can not be permitted, as required by specifications.

LOWER YELLOWSTONE DAM.

Bids are to be opened December 5, 1905, for a rock-filled, timber-cribbed dam acro the Yellowstone River at the headworks of the canal, about 18 miles northeast of Glendiv Mont.

RAILROAD LANDS.

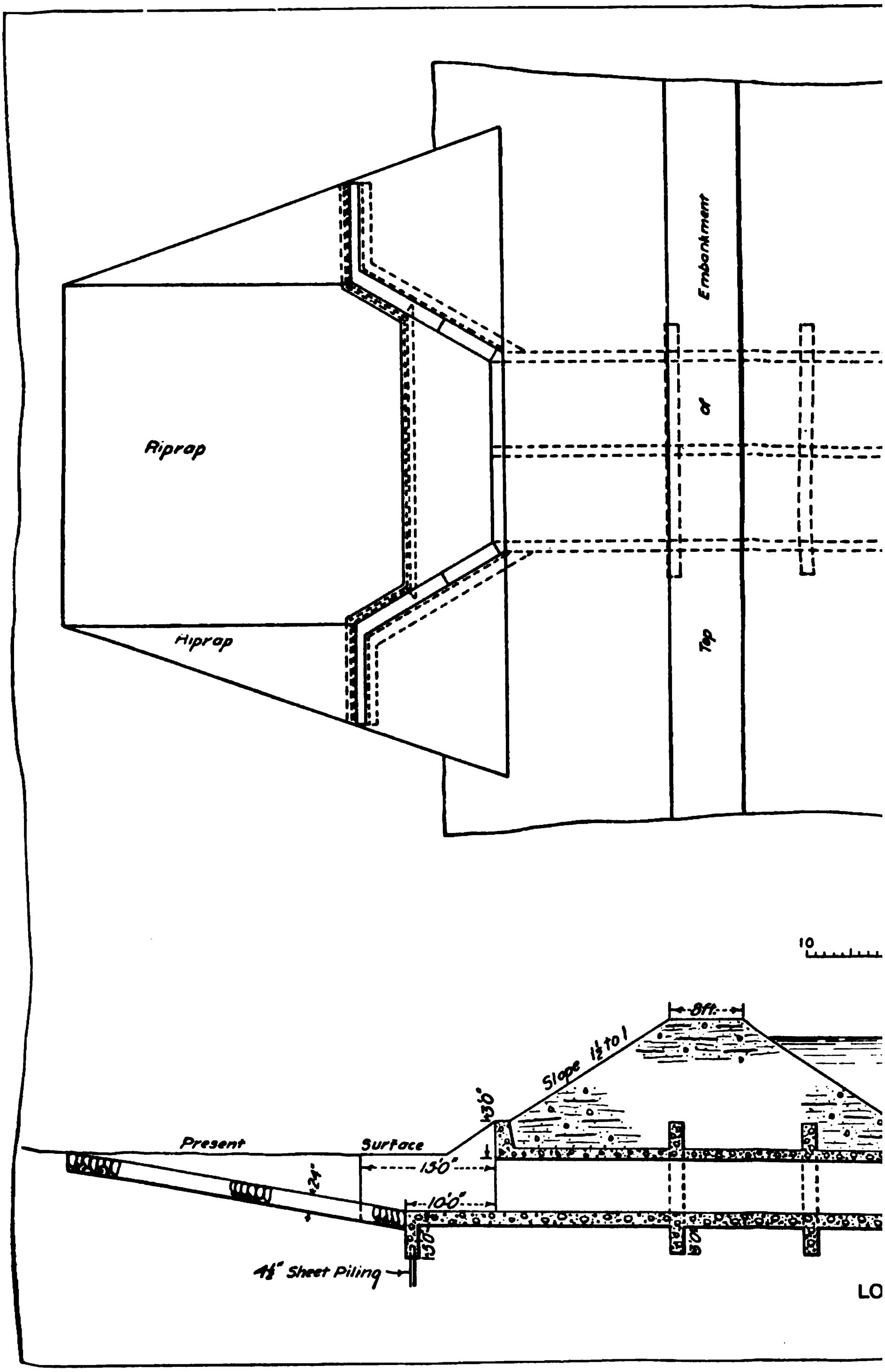
The Northern Pacific Railway Company, before building, was granted by the National Government all odd sections in a strip of land 40 miles each side of its line, with a 10-mile indemnity strip on each side of the 40-mile strip through Montana; consequently the company owns a large amount of land in this project. This land is held under the name of the Northwestern Improvement Company. Arrangements have been made between the Reclamation Service and the Northern Pacific Railway Company whereby their unsold lands within the project will be sold at $2.50 per acre and only to those who are eligible for a water right. The purchaser will also be governed by the rules and regulations of the Reclamation Service and can not obtain title to the land until payment for water right is completed. Following is form of contract which the railway company will execute with all purchasers of its lands within the Lower Yellowstone project:

This agreement, made this....day of......, between NORTHWESTERN IMPROVEMENT COMPANY, a corporation duly incorporated under the laws of the State of New Jersey, party of the first part, and ...., of............, in the county of...... and State of......, party of the second part, witnesseth:

The party of the first part, in consideration of the sum of......dollars, to be paid as hereinafter agreed, and of the faithful performance of the covenants, agreements, and conditions hereinafter expressed on the part of the party of the second part, agrees to sell to the party of the second part the parcel.. of land situate and being in the county of...... and State of... .., described as follows, to wit:..

....

of section number......, in township number...... north, of range number......, of the......principal meridian, containing......acres, more or less, according to the United States Government survey, together with the hereditaments and appurtenances thereunto belonging, subject, however, to an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easement in the public for any public road or roads heretofore laid out or established, and now existing, over and across any part of said described lands; but excepting from said lands such part thereof for canal right of way and other irrigation works as the United States Reclamation Service may determine to be necessary in connection with the construction, maintenance, and operation of the .... system already constructed or about to be constructed by the United States under the act of Congress approved June 17th, 1902.

The party of the second part covenants and agrees to purchase of the party of the first part the above-described lands and to pay therefor the sum of......dollars, with interest at six per cent per annum, in the manner following, that is to say: The sum of......at or before the execution of this contract, the receipt of which is hereby acknowledged:

The sum of $......principal, $......interest, on the....day of......, A. D. ....., payable at the office of the treasurer of said first party.

In case the party of the second part shall fail to pay when due any installment of principal or interest specified above, or to pay any taxes or assessments before the date when the same shall become delinquent, or shall be in default in respect of any other condition of this agreement, then the whole amount of principal unpaid shall, at the option of the party of the first part, become due and payable forthwith without notice. The party of the second part covenants and agrees, within ninety (90) days from the date hereof, to become a member of the ...... Water Users' Association, a corporation organized under the laws of Montana, and to acquire or apply to the United States for a water right under said act of Congress approved June 17th, 1902, for all the land included in this contract, which said United States shall determine can be irrigated from the ...., and thereafter to continue a member of said Water Users' Association and to comply with all the requirements of the United States with regard to such water right. If the second party shall, from any cause whatsoever, fail to become a member of said Water Users' Association within the period above stated, or shall fail to acquire or contract to acquire such water right within such period (or within ninety days after public notice has been given by the United States that applications for such water rights may be made, if such notice has not heretofore been given), then the party of the first part will repay to the party of the second part all moneys received by it hereunder, but without interest thereon; and thereupon this contract shall become null and void and all rights of the party of the second part thereunder shall cease and determine.

If the party of the second part, after becoming a member of said Water Users' Association or after contracting to acquire such water right, shall, by his default, lose such membership or forfeit such water right, then this contract shall become null and void and all right of the party of the second part hereunder shall cease and determine and he shall forfeit all payments made hereunder.

The party of the second part covenants and agrees that so long as this contract remains in force he will, before the same become delinquent according to law, pay all taxes and assessments, ordinary and extraordinary, that may be levied or assessed or that may become chargeable on said premises, and that no buildings or improvements now on said land, or that shall hereafter be placed thereon, shall be removed therefrom, but they shall be and remain the property of the party of the first part until this contract shall be fully performed by the party of the second part. Should default be made in payment of the principal or interest aforesaid, or in the payment of the taxes or assessments upon said land, or in the performance of any covenant herein contained, then and in such case this agreement, at the option of said party of the first part, shall be null and void, and all payments that shall have been made, and all buildings and improvements on said land, shall be and forever remain the absolute property of the party of first part, it being expressly understood and agreed that time is of the essence of this contract.

Upon full and prompt performance by the party of the second part of each and every the said covenants and agreements by him to be performed, and when, and not before, the second party has acquired full title from the United States to a water right to all of the land included in this contract which can be irrigated from the............, the party of the first part will execute and deliver to the said party of the second part a deed of conveyance of the said land upon surrender and delivery to the party of the first part of this paper.

Notice of the cancellation of this contract for any breach thereof, or notice of the exercise of any other right reserved to the first party herein where this contract requires notice, shall be addressed to the party of the second part, directed to the post-office named below, and deposited in a United States post-office, which shall constitute a good and sufficient notice and service thereof.

No assignment or transfer of any interest in this agreement or said premises less than the whole will be recognized by said party of the first part under any circumstances or in any event whatever, and no assignment shall be binding upon the company unless approved by its land commissioner; and no assignment or transfer of any interest in this contract or in said premises will be recognized, accepted, or approved unless accompanied by an assignment of the water right appurtenant thereto, duly approved by the proper officer of the United States, running to the same person to whom assignment of this contract may be made.

Except as herein otherwise provided this contract shall bind and inure to the benefit of the respective heirs, representatives, successors, and assigns of both parties.

In witness whereof the party of the first part, by its land commissioner, and the party of the second part have hereunto subscribed their names in duplicate the day and year first above written.

Lines numbered .... stricken out before the execution hereof.

NORTHWESTERN IMPROVEMENT COMPANY,
Attest: ...., By............,
Chief Clerk. *Land Commissioner.*
Witnesses to signature of purchaser: ...., *Purchaser.*
(Two witnesses required.) ...., *Purchaser.*
.... Post-office address:............
.... County of......

N. B.—This contract can not be signed by another for the purchaser excepting under a properly executed power of attorney, which must accompany the contract. In cases where purchaser can not write his name, his execution of the contract by making his mark must be acknowledged before a notary public under seal.

WATER USERS' ASSOCIATION.

During the fall and winter of 1904 and winter of 1905, a water users' association was formed under the name of the Lower Yellowstone Water Users' Association, and practically all the land under the canal was brought into the association. Although the people were very enthusiastic regarding the matter of obtaining water for their lands, the work of organizing was very difficult, since the people are so widely scattered. Considerable difficulty was also found in making the articles of incorporation conform to the State laws of Montana. The association completed its organization and entered into a contract with the Secretary of the Interior on May 31, 1905, authorizing the Secretary of the Interior to build the project. The articles of incorporation, contract, agreement, and by-laws are in general in accordance with the standard form of the Reclamation Service.

OPERATIONS IN 1905.

Early in April the engineering force was transferred from the Denver office to the field. Buildings to serve for headquarters were at once erected at La Mesa, about 14 miles from the headworks. These buildings consist of a general office building, mess house, dormitories, project engineer's house, stable, and necessary storehouses, sheds, etc. These buildings, although temporary in character, were built in such a manner that they can be used throughout the year. A permanent building was erected at the headworks for use as an office building that will serve as a house for the gatekeeper when the project is completed. A stable and bunk house have also been erected at the headworks, as construction work will continue there for about two years.

The first 34 miles of main canal have been cross sectioned and revised. Thirty-three more miles of main canal and the lateral system have been located on the ground, as well as a system of waste ditches. In the office, plans and specifications for the Lower Yellowstone dam were worked up, as well as plans and specifications for 33 more miles of main canal and 74 miles of laterals, together with structures for same.

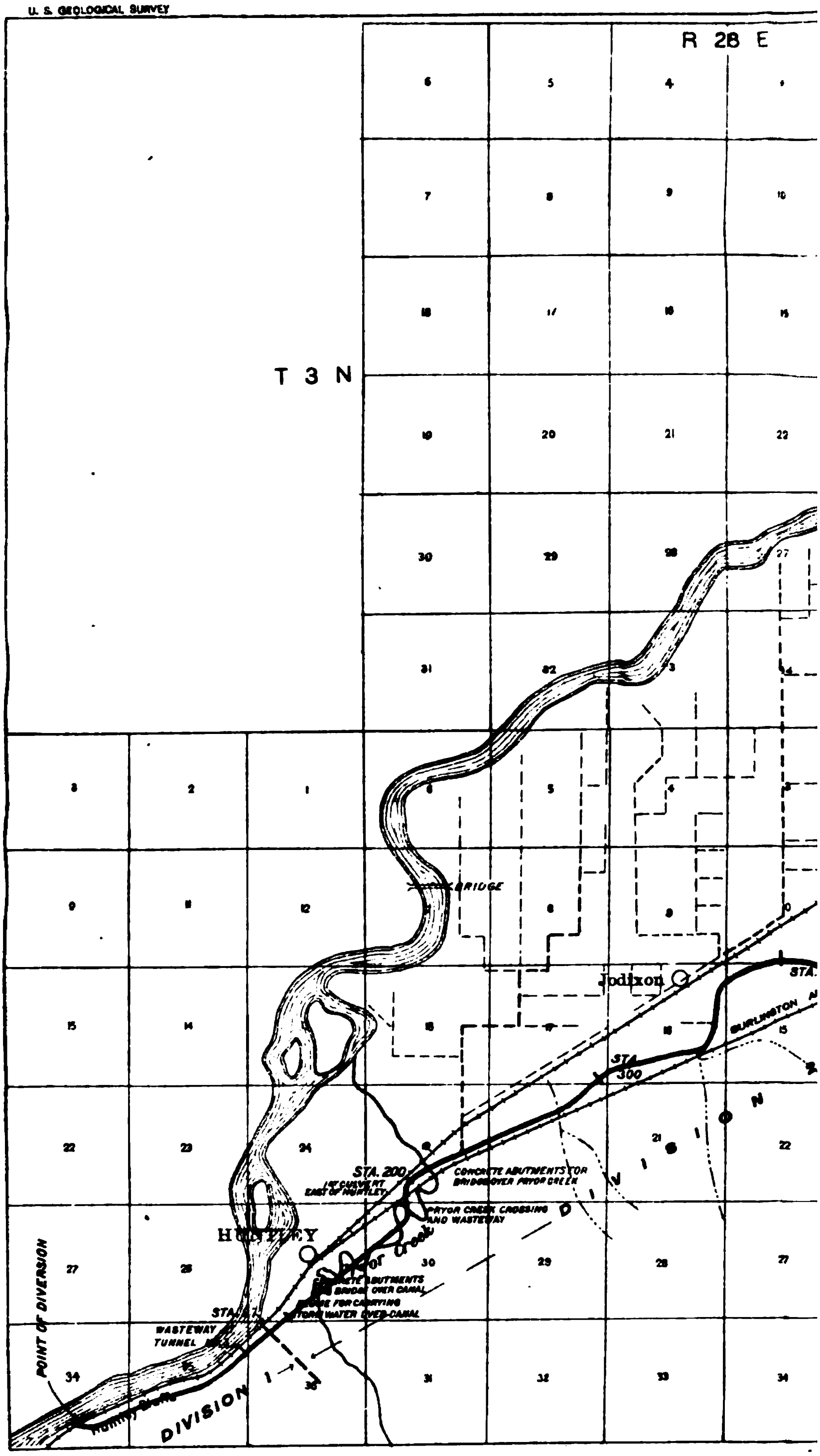
EXPENDITURES.

The expenditures on the Lower Yellowstone project to September 30, 1905, were as follows:

Expenditures on Lower Yellowstone project to September 30, 1905.

Main canal structures:		
Charles Stabern	$783.94	
Deadwood Construction Company	389.90	
		$1,173.84
Telephone line, E. A. Hess		2,179.58
Preliminary examination		17,101.00
Final surveys		28,824.00
Engineering		17,383.00
Administration		20,861.22
Total		87,522.64

U. S. GEOLOGICAL SURVEY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STA. 200
1ST CULVERT EAST OF HUNTLEY
CONCRETE ABUTMENTS FOR BRIDGE OVER PRYOR CREEK
PRYOR CREEK CROSSING AND WASTEWAY
HUNTLEY
Pryor Creek
CONCRETE ABUTMENTS FOR BRIDGE OVER CANAL
FLUME FOR CARRYING STORM WATER OVER CANAL
STA. 7
WASTEWAY TUNNEL NO. 1
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HUNTLEY PROJECT.

LOCATION.

The lands under the Huntley project are situated in the Yellowstone Valley and extend n a compact body from Huntley to Bull Mountain station on the Northern Pacific Railway. The lands lie south of the Yellowstone River, at an altitude of about 3,000 feet above sea level, within the ceded strip of the Crow Indian Reservation, which will be opened o settlement under the provisions of the act of Congress approved April 27, 1904. Bilings is the general supply point for this country and is about 13 miles from Huntley by ailroad. Huntley is at the junction of the Burlington and Northern Pacific railways, and a Government town site will be laid out there, as well as at several other points within he tract. Plate XXVI shows the general position of the towns and railroads with reference to the irrigable lands and main canal.

GENERAL DESCRIPTION.

The Huntley project was outlined during the season of 1904, when a preliminary survey was made and a gaging station established on the Yellowstone River near Billings. The surveys were worked up during the following winter, and plans were made for the irrigation of from 30,000 to 35,000 acres of land. The size and elevation of a main canal were decided on, and a paper location of the canal line was made. The first 2 miles of the line had to be located along the Huntley Bluffs, adjacent to the Northern Pacific Railway tracks. It was found desirable to carry the canal on the south side of the railway and away from the river, this necessitating three tunnels. The length of the tunnels are as follows: No. 1, 600 feet long, No. 2, 1,550 feet long, and No. 3, 390 feet long, making an aggregate length of 2,540 feet. The tunnels are 9.2 feet wide and about 9 feet high at the center of the arch. They will be driven through a rather soft sandstone, and the finished tunnel will have a lining of concrete from 6 to 12 inches thick. At Pryor Creek there will be a cut-off and a grade crossing (Pl. XXXI). The designs for all the structures have been gone over and working drawings made. All of the structures on the main canal (Pls. XXVII and XXVIII) are to be of concrete, plain and reenforced, and are to be of the most substantial and permanent form.

The power plant (Pls. XXIX and XXX) is one of the interesting features of this project. The canal line from Huntley eastward follows the Burlington railroad to a point beyond Ballantine, where it was necessary to put in a drop of about 34 feet, in order to keep the main canal at the foot of the bench and in good ground for construction. The quantity of water carried at this point is about 240 second-feet. When the plant is in operation the water passes through a turbine having a vertical shaft, on which is mounted a centrifugal pump, fed from the pressure pipe. The pump lifts a portion of the water—about 56 second-feet—to a height of 57 feet, where it enters the high-line canal, which covers the bench lands between Ballantine and Fly Creek, and adds about 3,000 acres to the irrigable lands. The operation of the power plant is intended to be nearly automatic. The plant is simple and durable and the cost of operation and maintenance will therefore be very low.

The power thus rendered available will be used to pump a portion of the water on the bench lands between Fly Creek and Ballantine. Another drop was found necessary, but it has not been planned to use the power at present.

CONTRACTS.

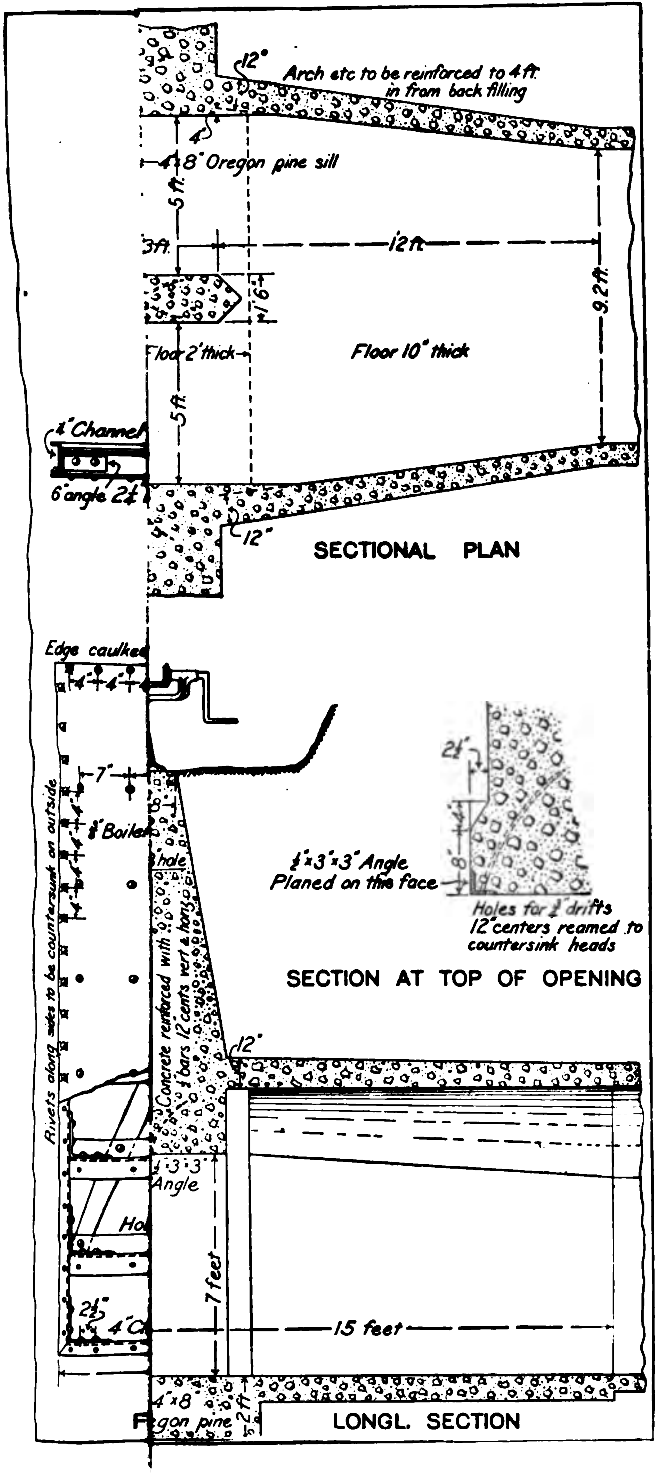
Plans were made for the construction of the main canal and the necessary structures in connection therewith. Bids for the main canal and structures were opened June 28. Following is a summary of the bids received:

Bids for structures, Huntley project, Montana.

Work or material.	Quantity.	W. D. Lovell, Minneapolis, Minn.[a]		Deadwood Construction Co., Deadwood, S. Dak.[a]		Charles Spear Billings, Mon	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amou
Excavation:							
Class 1	10 000 cubic yards	$0.65	$6,500.00	$0.30	$3,000.00	$1.00	$10,00
Class 2	500 cubic yards	1.00	500.00	.40	200.00	.65	325
Class 3	do	2.00	1,000.0	.90	450.00	1.25	625
Overhaul	1 000 cubic yards	.025	25.00	.02	20.00	.05	50
Puddling	500 cubic yards	.50	250.00	.50	250.00	.60	300
Riprap	1,000 cubic yards	3.50	3,500.00	6.00	6,000.00	4.50	4,500.0
Rubble wall	200 cubic yards	3.50	700.00	4.50	900.00	5.40	1,080.0
Coarse gravel	100 cubic yards	1.00	100.00	.75	75.00	.80	80.0
Concrete:							
Class 1	400 cubic yards	3.73	1,492.00	6.40	2,560.00	5.70	2,280.00
Class 2	1,200 cubic yards	3.98	4,776.00	7.50	9,000.00	9.50	11,400.0
Steel bridge:							
No. 1	42-foot span		[b] 596.00		850.00		1,400.0
No. 2	60-foot span		[c] 986.00		1,300.00		1,800.0
Gates and guides	6,000 pounds	.06	360.00	.06	360.00	.08	480.0
Stands with shaft, complete.	4	150.00	600.00	100.00	400.00	150.00	600
Steel for concrete reenforcement.	120,000 pounds	.0288	3,456.00	.035	4,200.00	.035	4,200
Tile drain pipe, 8-inch	1,500 linear feet	.45	675.00	.50	750.00	.40	60
Cast-iron pipe, 8-inch	50 linear feet	1.50	75.00	1.50	75.00	1.50	7
Cast-iron valves, 8-inch.	3	20.00	60.00	25.00	75.00	55.00	1
Flashboards	150	2.75	412.50	1.00	150.00	1.00	15
Pumping station:							
Item "A"	Building by-pass and auxiliary structures.		7,750.00		7,500.00		11,000
Item "B"	Change in length of by-pass, if brick.	25.00		12.55		28.00	
Item "C"	Same as "A," but with concrete by-pass.		7,450.00		7,200.00		10,800.00
Item "D"	Change in length of by-pass, if concrete.	20.00		6.85		25.00	
Total (with item "A").			33,813.50		38,115.00		51,110.00
Total (with item "C").			33,513.50		37,815.00		50,910.00

[a] Condition in bid: Contract must be for all items or nothing.
[b] Condition in bid: For wooden joists; if steel joists are used increase this amount by $100.
[c] Condition in bid: For wooden joists; if steel joists are used increase this amount by $150.

U. S. GEOLO[illegible] ANNUAL REPORT RECLAMATION SERVICE PL. XXVII


12"
Arch etc to be reinforced to 4 ft in from back filling
4'
4"×8" Oregon pine sill
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3 ft
12 ft
1'6"
9.2 ft
Floor 2' thick
Floor 10" thick
5 ft
4" Channel
6" angle 2½"
12"
SECTIONAL PLAN
Edge caulked
4" 4"
7"
⅜" Boiler
hole
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Concrete reinforced with ½" bars 12" cents vert & horiz
½"×3"×3" Angle Planed on this face
2½"
8"
Holes for ½" drifts 12" centers reamed to countersink heads
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Bids for structures, Huntley project, Montana—Continued.

Work or material.	Cotton Bros. & Co., Oakland, Cal.[a]		Vulcan Iron Works, Chicago, Ill.		William Bayley Co., Springfield, Ohio.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:						
Class 1	$0.55	$5,500.00				
Class 2	.90	450.00				
Class 3	1.30	650.00				
Overhaul	.02	20.00				
Puddling	.75	375.00				
Riprap	2.50	2,500.00				
Rubble wall	4.00	800.00				
Coarse gravel	1.00	100.00				
Concrete:						
Class 1	10.00	4,000.00				
Class 2	10.50	12,600.00				
Steelbridge:						
No. 1		900.00				
No. 2		1,200.00				
Gates and guides	.12	720.00	$0.0949	$569.40	$0.12	$720.00
Stands with shaft, complete	100.00	400.00	91.90	367.60	150.00	600.00
Steel for concrete reenforcement	.04	4,800,00				
Tile drain pipe, 8-inch	1.00	1,500.00				
Cast-iron pipe, 8-inch	2.00	100.00				
Cast-iron valves, 8-inch	75.00	225.00				
Flashboards	.30	45.00				
Pumping station:						
Item "A"		17,200.00				
Item "B"	30.00					
Item "C"		16,700.00				
Item "D"	25.00					
Total (with item "A")		54,085.00				
Total (with item "C")		53,585.00				

Work or material.	Midland Bridge Co., Kansas City, Mo.		W. H. Backus & Son, Portland, Oreg.	
	Unit price.	Amount.	Unit price.	Amount.
Excavation:				
Class 1				
Class 2				
Class 3				
Overhaul				
Puddling				
Riprap				
Rubble wall				
Coarse gravel				
Concrete:				
Class 1				
Class 2				
Steel bridge:				
No. 1		[a] $683.00 [b] 563.00		

[a] With steel rails and joists.

[b] With wooden rails and joists.

Bids for structures, Huntley project, Montana—Continued.

Work or material.	Midland Bridge Co., Kansas City, Mo.		W. H. Backus & Son, Portland, Oreg.	
	Unit price.	Amount.	Unit price.	Amount.
Steel bridges—Continued.				
No. 2		a$1,176.00 b$943.00		
Gates and guides				
Stands with shaft, complete				
Steel for concrete reenforcement			$0.037	$4,440.00
Tile drain pipe, 8-inch				
Cast-iron pipe, 8-inch				
Cast-iron valves, 8-inch				
Flashboards				
Pumping station:				
Item "A"				
Item "B"				
Item "C"				
Item "D"				
Total (with item "A")				
Total (with item "C")				

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a With steel rails and joists.

b With wooden rails and joists.

Bids for main canal, Huntley project, Montana.

DIVISION 1.

Kind of work.	Quantity.	Nick Hughes, Butte, Mont.		Griffiths & McDermott, Chicago, Ill.		Callahan Bros., Phelan & Shirley, Omaha, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Dry excavation:							
Class 1	35,000 cubic yards	$0.17	$5,950.00	$0.17	$5,950.00	$0.17	$5,950.00
Class 2	14,000 cubic yards	.50	7,000.00	.33	4,620.00	.40	5,600.00
Class 3	29,000 cubic yards	.97	28,130.00	.85	24,650.00	1.15	33,350.00
Wet excavation:							
Class 1	20,000 cubic yards	.50	10,000.00	.25	5,000.00	.40	8,000.00
Classes 2 and 3	1,000 cubic yards	1.50	1,500.00	1.00	1,000.00	1.40	1,400.00
Overhaul	do	.10	100.00	.015	15.00	.02	20.00
Tunnel:							
Type 1	900 linear feet	12.00	10,800.00	33.00	29,700.00	35.85	32,265.00
Type 2	315 linear feet	13.00	4,095.00	39.00	12,285.00	45.85	14,242.75
Type 3	300 linear feet	15.50	4,650.00	45.00	13,500.00	49.85	14,955.00
Concrete:							
Class 1	2 200 cubic yards	3.50	7,700.00	6.25	13,750.00	8.00	17,600.00
Class 2	100 cubic yards	6.00	600.00	6.75	675.00	9.00	900.00
Setting gates	40,000 pounds	.025	1,000.00	.015	600.00	.02	800.00
Riprap	100 cubic yards	4.00	400.00	1.25	125.00	2.00	200.00
Rubble wall	do	5.00	500.00	2.25	225.00	2.50	250.00
Total for division 1			ab82,425.00		112,095.00		135,732.75

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a Lowest bid for division.

b Condition in bid: For whole division.

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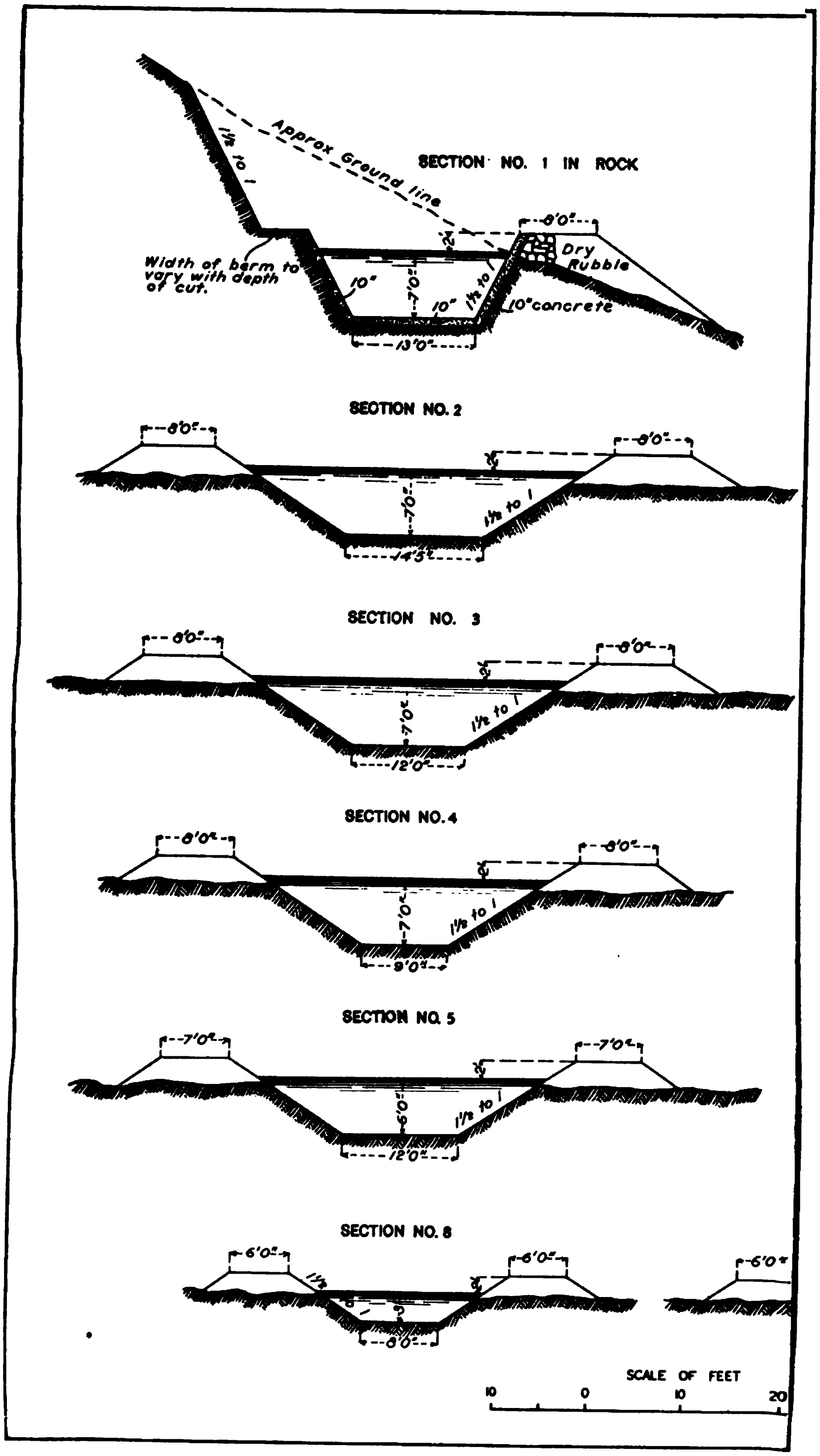
U. S. GEOLOGICAL SURVEY



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Bids for main canal, Huntley project, Montana—Continued.

DIVISION 1—Continued.

Kind of work.	W. D. Lovell, Minneapolis, Minn.		Cotton Bros. & Co., Oakland, Cal.		Charles Spear, Billings, Mont.		James Forrestal Co., St. Paul, Minn.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Dry excavation:								
Class 1	$0.21	$7,350.00	$0.23	$8,050.00	$0.50	$17,500.00		
Class 2	.74	10,360.00	.60	8,400.00	.60	8,400.00		
Class 3	.99	28,710.00	1.05	30,450.00	.90	26,100.00		
Wet excavation:								
Class 1	.63	12,600.00	.27	5,400 00	.75	15,000.00		
Classes 2 and 3	1.50	1,500.00	2.50	2,500.00	1.10	1,100.00		
Overhaul	.02	20.00	.02	20.00	.025	25.00		
Tunnel:								
Type 1	39.00	35,100.00	29.00	26,100.00	39.00	35,100.00		
Type 2	42.00	13,230.00	31.00	9,765.00	42.00	13,230.00		
Type 3	49.00	14,700.00	33.00	9,900.00	43.00	12,900.00		
Concrete:								
Class 1	3.73	8,206.00	7.00	15,400.00	6.00	13,200.00		
Class 2	4.00	400.00	8.00	800.00	7.00	700.00		
Setting gates	.015	600.00	.03	1,200.00	.02	800.00		
Riprap	3.50	350.00	2.75	275.00	3.00	300.00		
Rubble wall	3.50	350.00	3.00	300.00	3.00	300.00		
Total for division 1		133,476.00		[a]118,560.00		[a]144,655.00	(b)	(b)

DIVISION 2.

Kind of work.	Quantity.	Nick Hughes, Butte, Mont.		Griffiths & McDermott, Chicago, Ill.		Callahan Bros., Phelan & Shirley, Omaha, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:							
Class 1	305,000 cubic yards	$0.15	$45,750.00	$0.115	$35,075.00	$0.15	$45,750.00
Class 2	100 cubic yards	.60	60.00	.30	30.00	.30	30.00
Class 3	do	1.50	150.00	.75	75.00	.80	80.00
Overhaul	20 000 cubic yards	.10	2,000.00	.015	300.00	.02	400.00
Riprap	100 cubic yards	5.00	500.00	1.50	150.00	2.00	200.00
Total for division 2.			[c]48,460.00		[d]35,630.00		46,460.00

Kind of work.	W. D. Lovell, Minneapolis, Minn.		Cotton Bros. & Co., Oakland, Cal.		Charles Spear, Billings, Mont.		James Forrestal Co., St. Paul, Minn.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:								
Class 1	$0.139	$42,395.00					$0.17	$51,850.00
Class 2	.80	80.00					1.00	100.00
Class 3	1.20	120.00					2.00	200.00
Overhaul	.015	300.00					.015	300.00
Riprap	3.50	350.00					4.00	400.00
Total for division 2		43,245.00	(b)	(b)	(b)	(b)		52,850.00

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[a] Condition in bid: For whole of division 1 or nothing.

[b] No bid.

[c] Condition in bid: For whole division.

[d] Lowest bid for division.

Bids for main canal, Huntley project, Montana—**Continued.**

DIVISION 3.

Kind of work.	Quantity.	Nick Hughes, Butte, Mont.		Griffiths & McDermott, Chicago, Ill.		Callahan Bros., Phelan & Shirley, Omaha, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:							
Class 1	350,000 cubic yards	$0.15	$52,500.00	$0.12	$42,000.00	$0.15	$52,500.00
Class 2	100 cubic yards	.60	60.00	.40	40.00	.30	30.00
Class 3	do	1.50	150.00	.80	80.00	.80	80.00
Overhaul	20,000 cubic yards	.10	2,000.00	.015	300.00	.02	400.00
Riprap	100 cubic yards	5.00	500.00	1.50	150.00	2.00	200.00
Total for division 3.			[a]55,210.00		[b]42,570.00		53,210.00
Grand total			186,095.00		190,295.00		235,402.75

Kind of work.	W. D. Lovell, Minneapolis, Minn.		Cotton Bros. & Co., Oakland, Cal.		Charles Spear, Billings, Mont.		James Forrestal Co., St. Paul, Minn.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:								
Class 1	$0.169	$59,150.00					$0.17	$59,500.00
Class 2	.85	85.00					1.00	100.00
Class 3	1.00	100.00					2.00	200.00
Overhaul	.02	400.00					.015	300.00
Riprap	4.00	400.00					4.00	400.00
Total for division 3		60,135.00	([c])	([c])	([c])	([c])		60,500.00
Grand total		236,856.00						113,350.00

[a] Condition in bid: For whole division.

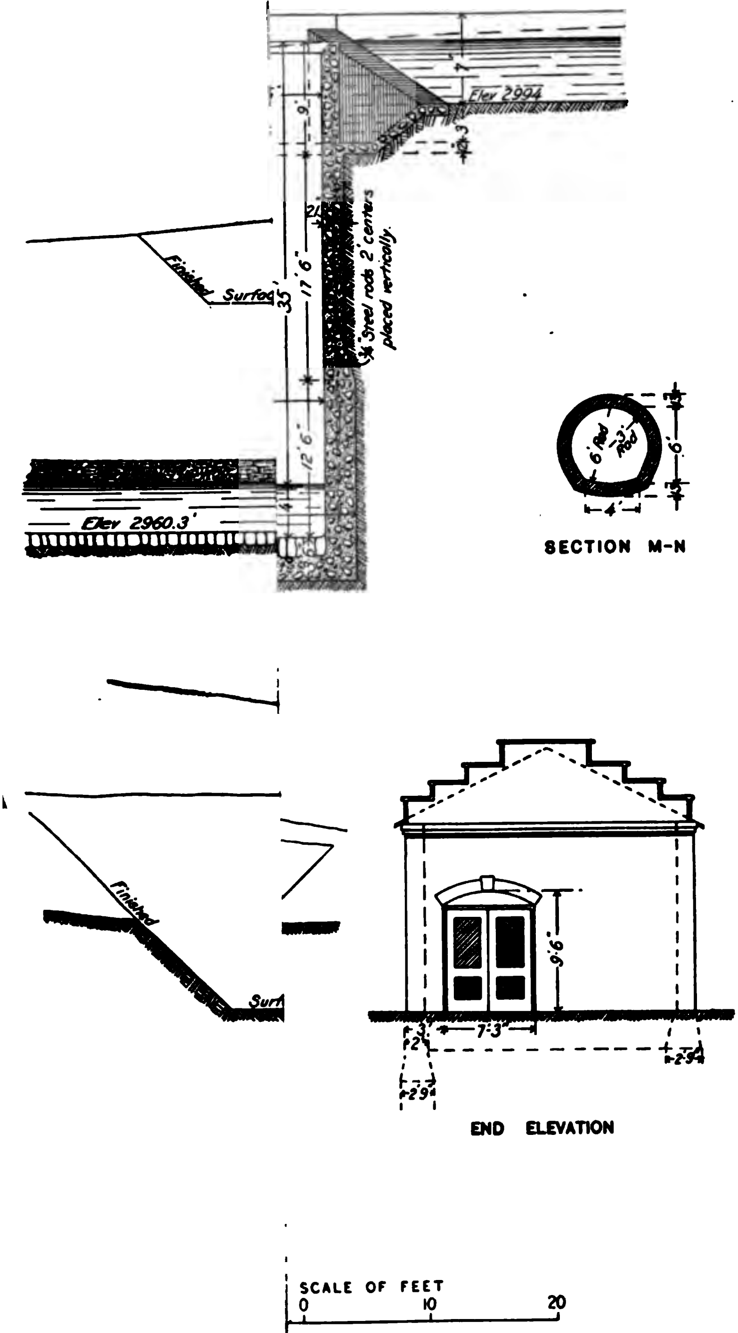
[b] Lowest bid for division.

[c] No bid.

The contract for the structures was awarded to W. D. Lovell. The contract for division 1 of the canal was awarded to Nick Hughes, the lowest bidder, who refused to execute it. It was then awarded to Griffiths & McDermott, the next lowest bidder. They also refused to execute the contract, and it has been awarded to Cotton Bros. & Co. The contract for divisions 2 and 3 was also awarded Griffiths & McDermott, and on their refusal to do the work division 2 was awarded to W. D. Lovell and division 3 to Callahan Bros., Phelan & Shirley.

There has been a long delay in getting contractors started on the main canal, but a representative of the contractor for the structures appeared on September 18, 1905, and some work will be done before winter sets in. It is also expected to start the tunnel work this winter, as the tunnels can be driven most advantageously during low water. The work has been planned with the idea of putting water on the land in the spring of 1907, and this will be done unless further delays occur.

Bids for about 7,000 barrels of Portland cement were opened September 5, 1905, and the award was soon afterwards made to the Illinois Steel Company, cement department, for $1.10 per barrel f. o. b. cars Chicago, Ill. Bids for a telephone line and for the distribution system for the Huntley project will be opened December 15.



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WATER SUPPLY.

The Huntley canal diverts, under normal conditions, 400 second-feet from Yellowstone River. The headgate structure and canal elevation have been so arranged that water is taken out down to the bottom of the river. This arrangement avoids an expensive weir and precludes the possibility of a shortage of water.

The discharge of Yellowstone River at the Billings gaging station during 1904 varied from a minimum of 2,740 second-feet in December, to a maximum of 32,580 second-feet in June. Even the minimum discharge in midwinter is so far ahead of the present appropriations that the question of water supply may be dismissed with the statement that there is a bountiful supply, and that proper filings, according to Montana law, have been made on 750 cubic feet per second. The excess filed on is to provide for its use for domestic and power purposes.

EXPENDITURES.

The expenditures on the Huntley project to September 30, 1905, for preliminary examination, final surveys, design of structures, construction of office buildings, quarters, and storehouses and administration were $30,272.90.

SUN RIVER PROJECT.[a]

The location of the Sun River project and the extent of previous examinations of it were described in the Third Annual Report of the Reclamation Service, pages 307 to 313, and shown on Pl. XXIX. Field work was resumed in March, 1905, being the second season.

NORTH SIDE.

DIVERSION LINE.

The detailed surveys of 1904 were extended up the river above the falls, the same scale, 50 feet to the inch, with 5-foot contours, being used, the result being that the added information has caused an abandonment of the plan of putting the diversion weir where first contemplated, largely on account of the 65 feet of necessary subaqueous foundation and the fact that current-meter observations indicate the probable existence of hidden underground channels. The location has been moved about 500 feet upstream, to a point just above the brink of the lower fall, where the river is 54 feet wide. The weir will have a length of 170 feet and a height of 72 feet. Here solid limestone rock extends entirely across the canyon, the falls indicate that the formation is solid, and there is no doubt that the canyon was formed by erosion and did not follow a fault or crevice. To make doubly sure several drill holes will be sunk along the axis of the dam.

At the weir the north-side diversion line starts into a tunnel, the first 1,000 feet being through very solid limestone. From this point to station 50 the tunnel was continued in preference to an open cut because the steep side-hill character of the country makes the former the cheaper, the location being carried far enough into the hill to get secure ground and yet close enough to the stream to allow frequent short adits to be used in construction to cheapen the cost of mucking. The character of the material to be encountered from the end of the limestone is a soft sandstone with nearly horizontal stratification, and this portion of the tunnel will have to be lined.

This line has been located throughout the entire distance to the Stone Johnnie reservoir, 13.6 miles, and, while it extends through an apparently difficult country, is very satisfactory, several cut-offs, improving on the preliminary survey of 1904, having been made. This line will have been tested for classification purposes by test pits and auger holes before the end of the field season.

The upper portion of the line was kept up to provide sufficient grade to permit the highest safe velocity through the tunnel, to diminish the cross section, and to get on the best ground for construction beyond the tunnel. At 8 miles the line runs into Arnold Coulee, where the water will follow the natural course for three-fourths of a mile, dropping 10 feet in this distance. In this coulee an earth dam 600 feet long and 35 feet in greatest height, protected on the upstream side with riprap, will divert the water into a canal again, whence it will run to the reservoir.

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[a] From report by S. B. Robbins.

George W. Weed has been in charge of all the location surveys made on this project this season.

STONE JOHNNIE RESERVOIR.

This reservoir was briefly mentioned on page 310 of the Third Annual Report, second edition. The surveys of 1904 were extended during the past season by W. T. Turner, topographer, and additional capacity of about 5,000 acre-feet was obtained. As several lake beds are embraced in the flooded area it has developed that a portion of the stored water will be available for use only through the Teton slope line, and another portion only through the Freezeout bench line, and the upper portion may be diverted to either line as future requirements demand. The following table gives the capacities of the reservoir at different elevations and also shows amount available for the different proposed uses:

Capacity of Stone Johnnie reservoir.

Contours, feet above sea level.	Area.	Capacity of section.	Total capacity.
	Acres.	*Acre-feet.*	*Acre-feet.*
4,300	106.09	787.9	787.9
4,310	190.56	1,483.2	2,271.1
4,320	342.64	2,666.0	4,937.1
4,330	490.20	4,164.2	9,101.3
4,340	676.20	5,779.0	14,880.0
4,350	837.20	7,564.0	22,444.0
4,360	1,052.60	9,297.0	31,741.0
4,370	1,542.60	14,006.0	45,747.0

FREEZEOUT BENCH LINE.

This line was dropped about 30 feet below the preliminary line of 1904 in order to take advantage of the storage of the Stone Johnnie reservoir, in which it heads. It has a length of 23.5 miles to the point where it drops into Spring Coulee, and the location has been run for this distance. The first 6½ miles runs through the rolling glacial country; then the line is supported along hillsides to attain the level bench at station 480. In this interval it has been thought advisable to put in two tunnels through glacial gravel to shorten the distance and insure better construction. The first tunnel will have a length of 2,200 feet and the second 2,000 feet.

Test pits dug along this line show that the material to be encountered will be a mixture of gravel and clay with a small amount of cemented gravel.

From the point where line reaches the bench to Spring Coulee there are about 11,500 acres of excellent irrigable land.

From Spring Coulee eastward no surveys were made this season, because the location must necessarily closely follow the preliminary line of 1904. Upon the Freezeout bench the canal will serve about 80,000 acres. The preliminary classification of this land will be made before the end of the season and will show a very large percentage of first-class land, as the soil is a very fertile sandy loam, more or less underlain and mixed with gravel, and is considered very desirable alfalfa ground. The reclaimable portion of this bench is in a compact body, about 18 miles long by 7 miles wide, with a gentle slope diagonally across it, which will allow a cheap distributing system. The slope is great enough for good drainage, and there should be no trouble from the rise of alkali. Very little preparation for cultivation will be necessary, as the surface is generally smooth, will need little grading, and has no growth of sagebrush, in the latter respect being similar to all other parts of Sun River project.

TETON SLOPE LINE.

After passing through the outlet tunnel of the Stone Johnnie reservoir the water for the Teton slope will run down a coulee into Deep Creek, and down this to the diversion weir in the NW. ¼ sec. 15, T. 23 N., R. 5 W., a total of about 12½ miles, through natural channels.

The weir as planned will be of concrete, 12 feet high and 100 feet long, with a 500-foot earth embankment on the west side to confine the water to the channel. Test pits sunk at this place to a depth of 14 feet below the bed of the stream show stiff clay mixed with gravel for foundation material.

The distributing canal starts on the east side of the creek at the weir, and after the first half mile begins to serve the bottom lands along the creek, gradually drawing away to the southward. After passing behind Priest Butte, at a distance of 7.2 miles from the head, two alternative lines were run, one across the Priest Butte sag, the other around the Freezeout basin. The sag line embraces 1.54 miles of canal and 4,400 feet of re-enforced concrete pipe, 9¼ feet inside diameter, the difference of elevation of the ends being 24½ feet and the greatest pressure being 59 feet. The basin line is 35.8 miles long, and waters the lands of the basin its entire length. If the main supply should be carried through the pipe the basin would have to be surrounded by laterals, consequently the comparison of cost embraces the items of pipe and 1.54 miles of main canal plus laterals against 35.8 miles of open canal. At present the plan of carrying the canal around the basin seems the cheaper. This sag is the same location which was considered in 1904 for the dam site in connection with the proposed Freezeout reservoir, as mentioned on pages 299–300 of Third Annual Report. The plan to use this site has been abandoned in favor of storage at Nos. 3, 5, and Stone Johnnie reservoir sites, largely on account of the cost of a supply canal and the fact that about 20,000 acres of very fine irrigable land would be flooded.

A drainage channel will have to be provided to keep floods and seepage water from irrigation below the natural surface of the Freezeout Lake. This channel will have a length of about 5½ miles and a maximum depth of 17 feet. It will drain into Priest Lake, lying north of the sag, and a similar channel will have to be provided from this lake to Teton River to prevent the rise of its natural surface. No survey of this line has yet been made, but its length will be about 3½ miles and its depth probably will not exceed that of the upper channel.

From the east end of the sag the main canal follows the general course of the Teton, covering the bottom lands south of the river and all the bench between it and the Teton-Sun divide, which consists of a low range of hills having a general east-and-west direction, the part west of the Montana and Great Northern Railway being known as the T. L. Ridge and that east of the railroad as the Teton Ridge.

The railroad crossing will necessitate a pipe 3,400 feet long, with 6-foot inside diameter, 27 feet difference in elevation of ends, and 50 feet maximum head. The line has been located for 6 miles east of the railroad crossing. There is opportunity to extend it still farther eastward if the water supply warrants, but enough land is covered by the present location to utilize all the water that is probably available for this diversion. If, however, nothing should be done toward reclaiming land on the south side this line may be extended to use the water now reserved to go south. The land covered by an extension would be mostly vacant.

The lands lying below the Teton slope line have been classified as well as practicable without topographic surveys as shown below:

Land lying below Teton slope line, in acres.

	First class.	Seco cla
	Acres.	*Acr*
Deep Creek to Priest Butte sag	5,440	[illegible]
Freezeout basin	19,755	[illegible]
Sag to Montana and Great Northern Railway	50,210	[illegible]
Montana and Great Northern Railway to end of line	23,320	......
Total	98,725	[illegible]

Until a topographic survey of the irrigable lands is made their exact area and classification can not be determined, but from the preliminary work already done it has been found that on the north side of Sun River there are some 183,700 acres of irrigable land under the canal lines now surveyed, without further extension of the Teton slope line. The ownership is divided approximately as follows: Private, 35 per cent; State, 8 per cent; Government, 57 per cent.

DAM SITE NO. 2.

The investigation as to the feasibility of attaining the required elevation for the north and south main canal lines by building the dam at Wilson's No. 2 site and diverting the was considered this season. A preliminary canal line was backed up on the north side from Stone Johnnie reservoir to and above this point, but the practicable height of dam there is not sufficient for the purpose, and it was not considered a safe site for a dam of the required height, over 100 feet, as the foundation and abutments consist of sandstone, in some much fractured and very soft anticlinal folds. Nor is there suitable building stone for a dam within a reasonable distance. Also the diversion line on the south side would be about 4 miles shorter if taken from the canyon, as the upper line passes over a hill which the Wilson No. 2 canal line passes around.

STORAGE IN THE MOUNTAINS.

In April W. T. Turner, topographer, took charge of the storage investigations in the mountains on the upper North Fork. As it happens, the main upper Sun River has been called the North Fork, and this is again divided into a north fork and a south fork. In the following description "North Fork" and "South Fork" refer to the north and south forks of the North Fork. A plane-table survey was made of the North Fork from below the confluence of the North and South forks to dam site No. 3 and above, including reservoir No. 3. This work was done on a scale of 1,000 feet to the inch, with a 10-foot contour interval. A survey was also made up the South Fork about one-half mile, to the falls. At this point a fall of 17 feet occurs in a horizontal distance of 340 feet through Sheep Reef Ridge.

It was thought that a high masonry dam below the confluence of the North and South forks, at a point where the main North Fork cuts through a hard limestone reef, would store the waters of both streams. This idea did not prove correct, as a 100-foot fall in about a mile on the North Fork above the dam site limits the storage capacity of that stream to 65,000 acre-feet for a 260-foot dam. In the South Fork occurs a fall of 40 feet in the first half mile, and as the river flows through a narrow canyon for 2 miles above the dam site the storage capacity would be small. The total storage capacity would not exceed 110,000 acre-feet.

Reservoir No. 4 on the South Fork was not considered, as no suitable dam site could be found.

Reservoir No. 3 is the only reservoir site in the mountains available for storage. Below s given the table of contents:

Capacity of North Fork Sun River reservoir above dam site No. 3.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
4,800	5	25	25
4,810	44	245	270
4,820	165	1,045	1,315
4,830	251	2,080	3,395
4,840	368	3,095	6,490
4,850	445	4,065	10,555
4,860	532	4,885	15,440
4,870	656	5,940	21,380
4,880	808	7,320	28,700
4,890	966	8,870	37,570
4,900	1,099	10,325	47,895
4,910	1,205	11,520	59,415
4,920	1,338	12,715	72,130
4,930	1,506	14,220	86,350
4,940	1,658	15,820	102,170
4,950	1,775	17,165	119,335
4,960	1,876	18,255	137,590
4,970	1,976	19,270	156,860

A low divide 2,000 feet west from dam site No. 3 makes it possible to provide a spillway for this site, from which the flood waters will flow into South Fork.

LIMESTONE REEF DAM SITE.

The dam site 500 feet below the confluence of the North and South Forks was first surveyed on a scale of 100 feet to the inch, with 5-foot contour interval. As stated elsewhere, the storage capacity of the dam at this location would be small, and dam site No. 3 was next considered.

DAM SITE NO. 3.

In the survey of dam site No. 3 a scale of 100 feet to the inch, with 2 -foot contour interval, was used. At this point a dam 190 feet high will give storage capacity of 156,860 acre-feet, with flood line to the 4,970-foot contour, the crest of the dam to have an elevation of 4,980. At this point the North Fork cuts through a hard granite reef (Sheep Reef), showing bed rock in the river bed, 50 feet in width.

On September 1 a diamond-drill crew began boring at this site. The foundation is very hard, fine-grained diorite, and a better foundation could not be desired. At first a masonry dam was contemplated, but the great distance of dam site from a railroad, about 72 miles, would make the cost of cement very high at place of construction. The idea was then developed of building a combination rock-and-earth-fill dam, and in September a number of men were employed to dig test pits to find what material was available. Test pits were dug from 9 to 25 feet deep, showing up plenty of material for earth fill within 2,000 feet of the dam site. This consists of clay, coarse and fine gravel, sand, and bowlders. Estimates show at least 1,166,000 cubic yards, taking depth as 18 feet. Much of the material is of greater depth, but as sufficient for all needs was prospected no further investigation seemed necessary. Within another 1,000 feet there is about as much yardage, and several times the amount required are within reach and at an elevation high enough to be sluiced into the fill. It is thought the best method of moving this material to the dam site will be by the hydraulic process. Water can be delivered for this purpose by building a small ditch, about 4 miles long, from Bear Creek, with 3,000 feet of pipe line, and the diversion may be made high enough to give an excellent working head. No gagings were made of Bear Creek, but 20 second-feet will probably be available during the summer and fall, and considerably more during the spring. Measurements will be made to determine low-water flow.

About 4,000 feet below dam site No. 3 is a large talus of diorite split off from the point of Sheep Reef lying between the forks, composed of rocks from 1 to 30 cubic yards in size, with a good portion varying from 1 to 6 cubic yards. It will probably be much cheaper to transport rock from this point to the dam by cableway, gravity tramway, or other method, than to blast the material from above the dam.

SPILLWAY.

Two test pits were dug in the spillway divide and bed rock was found in both holes at about the elevation of the proposed flood line. The material above rock is sand and gravel and can be excavated by hydraulic method and sluiced into the dam, making the actual cost of the spillway small. A head of 90 feet for washing the material from the spillway will give a head of about 240 feet for the lower earth near the dam site, which would be the first material to move, washing being carried higher up as the height of the dam increases.

OUTLET TUNNEL.

An outlet tunnel approximately 800 feet long, 10 by 10 feet in size, with a slight arch, is planned to pass through the east abutment. A tunnel of this size, with slope of 0.01, will discharge 2,200 second-feet. As the rock and earth fill could probably not be finished in one season after the subsidence of the spring floods, it would be necessary to construct the outlet tunnel first, to take care of the discharge during the construction of the dam. After finishing the tunnel the dam should be built to elevation 4,870 feet, or 80 feet above the stream bed. When work is resumed in the following year the outlet tunnel should readily discharge 4,000 second-feet under a 70-foot head, which would insure the safety of the work, as it is probable the North Fork has never had as great a flow as this.

SOUTH FORK DIVERSION.

A plane-table survey was made in the spring for a diversion canal from a point just below the confluence of the West Fork and South Fork to the spillway divide of reservoir No. 3. The South Fork waters could thus be brought to reservoir No. 3 with 7 miles of canal line, the spillway to be used both as an outlet for flood waters and an inlet for storage. This diversion would catch the flow of Elk, Goat, and Bear creeks en route. It is thought that reservoir No. 3 will not more than control the North Fork, and it is probable that it will never be necessary to supplement the supply from the South Fork.

POSSIBLE POWER DEVELOPMENT.

At the South Fork Falls power can be developed for use in construction. A low-water flow of 75 second-feet, with 50 per cent efficiency, will develop 72 horsepower.

Should the development of electric power become necessary for a pumping project within a reasonable distance, the South Fork diversion line could be developed by 6 miles of canal to a point where the South Fork cuts a steep bluff, with a flat just to the east available for location of power plant. Here a head of 230 feet, with discharge of 75 second-feet, would develop, with 50 per cent efficiency, 1,000 horsepower.

From reservoir No. 3, by a canal taken from the outlet tunnel to just below Limestone Reef dam site, a head of 100 feet can be had, with a canal approximately 1 mile in length. With a flow of 600 second-feet from May to September, inclusive, the irrigation season, about 3,400 horsepower (50 per cent efficiency) can be developed. A full reservoir early in the irrigation season, with the normal summer flow, will maintain this discharge.

SOUTH SIDE.

The reconnaissance of the country south of Sun River, suggested on page 313 of the Third Annual Report, has been completed during the past season.

ELK CREEK RESERVOIR SITE.

In June W. T. Turner made an investigation for storage on the upper South Fork. He ound only one site worthy of survey, on Elk Creek.

Capacity of Elk Creek reservoir.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
4,890	4.0	20	20
4,900	9.6	68	88
4,910	16.8	131	219
4,920	24.0	204	423
4,930	37.7	308	731
4,940	53.6	457	1,188
4,950	70.8	622	1,810
4,960	88.0	794	2,604
4,970	109.0	985	3,589
4,980	135.0	1,220	4,809
4,990	166.0	1,525	6,334
5,000	201.0	1,835	8,169

WILLOW CREEK RESERVOIR SITE.

F. F. Prendergast, assistant engineer, made preliminary surveys on the south side and found that it was possible to divert water from the North Fork at the canyon weir and carry it about 8 miles to the divide on the west side of Willow Creek. Here it may follow natural channels some 7 miles into Willow Creek at a point above reservoir No. 5 (Wilson's).

Mr. Turner made a detailed survey of this reservoir by plane-table methods on a scale of 1,000 feet to 1 inch, with 5-foot contours.

Capacity of Willow Creek reservoir.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
4,070	....	....	....
4,075	....	....	....
4,080	7	18	18
8,585	10	42	60
8,590	40	125	185
8,595	87	317	502
[a] 4,100	146	583	1,085
4,105	223	922	2,007
4,110	341	1,410	3,417
4,115	451	1,980	5,397
4,120	651	2,755	8,152
[b] 4,125	857	3,770	11,922
4,130	1,054	4,777	16,700
4,135	1,305	5,897	22,600
4,140	1,416	6,802	29,400
4,145	1,532	7,370	36,770
4,150	1,672	8,010	44,780
4,155	1,810	8,705	53,485
4,160	1,985	9,485	62,970
4,165	2,135	10,300	73,270
4,170	2,285	11,050	84,320

[a] Elevation of lower canal line.
[b] Elevation of upper canal line.

DRY CREEK RESERVOIR SITE.

From two different elevations, 25 feet apart, near the bottom of No. 5 reservoir, two preliminary lines were run eastward up the valley of South Fork, crossing that stream about 1½ and 2 miles, respectively, above Augusta, thence running eastward to Dry Creek. The distance by the upper and better line is 7 miles to South Fork, with a total length of 23 miles to Dry Creek.

Satisfactory storage not having been found on South Fork for its flood waters, it was planned to pick them up where the Augusta line crosses that stream and carry them to Dry Creek, where a storage site of 38,585 acre-feet capacity was found below the elevation of the supply canal. This was surveyed by plane-table methods on a scale of 1,000 feet to 1 inch, with 10-foot contours. To form the reservoir a dam 1,065 feet long, with a maximum height of 95 feet, would have to be constructed. This would be of earth, with a core wall. Three low auxiliary dams of earth would be necessary to fill gaps between knolls.

Capacity of Dry Creek reservoir.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
3,930	5.7	....	....
3,940	17.7	117	117
3,950	37.0	273	390
3,960	99.0	680	1,070
3,970	257.0	1,780	2,850
3,980	536.0	3,965	6,815
3,990	812.0	6,740	13,555
4,000	1,286.0	10,490	24,045
4,010	1,622.0	14,540	38,585

From the bottom of this reservoir the preliminary line was carried 3½ miles to the Simms Creek divide, where a lateral was surveyed 14 miles to take in the irrigable lands around the head of this creek, the main body of water being allowed to flow down the creek to be picked up again and carried 9 miles to the Crown Butte divide, whence it would run toward Missouri River through Muddy Creek. A high-line preliminary was carried eastward from the Crown Butte divide for about 28 miles, and another line from lower down the Muddy 22 miles to cover the Ulm flats, near the Missouri. These lines were run to obtain an idea of the location and area of the maximum amount of land which may be served by the South Fork supplemented by the North Fork.

AVAILABLE LAND.

The best tracts were those of the South Fork Valley near Augusta and portions of the old Fort Shaw Military Reservation. If the south side system were built, the latter lands could be served by means of the high line from Simms Creek. But in case it is deemed desirable to leave out the major portion of this subproject the reservation lands may be covered by a lateral taken from the main stream. The Augusta Valley, Fort Shaw, and the prior rights on the North Fork and main Sun River may be served by water stored in Willow Creek reservoir, as it lies above them all.

The policy toward the south side can not be foretold, as the farmers near Augusta now have a partial supply of water and are not enthusiastic about Government construction. Also lying east of South Fork, around Dry Creek and Simms Creek, are about 33,000 acres of land, withdrawn under the Carey Act and partially reclaimed by the State from the Dearborn. The status of these lands is very indefinite and unsatisfactory and action regarding their reclamation from Sun River must be deferred.

The Fort Shaw Reservation was in the hands of the War Department until July 22, 1905, when it was transferred to the Interior Department.

For the past ten years the old fort buildings and part of the reservation lands have been occupied by an Indian school. As this school has never been on a permanent basis, and as the status of the irrigable lands should be settled definitely while the Sun River project is under consideration, there being insufficient water to reclaim more than half the available land, it is desired that some definite action be taken by Congress at the coming session. To furnish data for an intelligent presentation and consideration of the subject a topographic survey of the irrigable portion of the reservation was made by Mr. Turner on a scale of 2,000 feet to 1 inch, with 10-foot contours, covering an area of 39.3 square miles, the map showing the areas irrigated, irrigable, farmed, and occupied by the school. A copy of this map and a report of the conditions are available for Congressional action.

The reclaimable areas upon the south side are shown in the following table:

Irrigable lands on south side of Sun River, Montana.

	Acreage.					Percentage.			
	Carey.	State.	Private.	Government.	Total.	Carey.	State.	Private.	Government.
Willow to Simms Creek	6,880	1,440	12,920	1,480	22,720	30.3	6.4	56.8	6.5
Simms Creek	5,760	160	2,160	240	8,320	69.2	1.9	25.9	3.0
Missouri Flats	....	2,800	14,480	7,440	24,720	....	11.4	58.5	30.1
Upper Muddy	....	1,560	17,960	6,720	26,240	....	6.0	68.4	25.6
Fort Shaw Reservation	....	....	....	15,080	15,080	....	....	....	100.0
Total	12,640	5,960	47,520	30,960	97,080	13.0	6.1	49.0	31.9

WITHDRAWALS.

Previous to 1905 the withdrawals of land for reservoir purposes, under the first form, consisted of T. 22 N., R. 3 W., the E. ½ of T. 22 N., R. 4 W., SW. ¼ of T. 23 N., R. 3 W., and SE. ¼ of T. 23 N., R. 4 W. for the Freezeout reservoir under date October 17, 1903, and secs. 1, 2, 3, 10, 11, 12 in T. 22 N., R. 7 W. for the Stone Johnnie reservoir under date November 3, 1904. On September 13, 1905, secs. 4, 5, 8, 9, 10, 15, 16, 21, 22, 23, 26, 27, T. 22 N., R. 10 W., and secs. 28, 29, 32, 33, T. 23 N., R. 10 W. were also withdrawn under the first form for reservoir No. 3. The reservation of lands for No. 5 was made about the time of the original Wilson surveys. All lands affected by the south-side subproject, including Dry Creek reservoir, were withdrawn under the first form on September 20, 1904.

WATER USERS' ASSOCIATION.

On August 30, at a meeting in Great Falls of the people of that place and the surrounding country, the possibilities of the Sun River project were explained, and they were informed concerning the matters which they must necessarily attend to themselves. An executive committee of three citizens was appointed to do whatever was found necessary to aid in pushing the project to construction and completion. A finance committee was also appointed, and has been very successful in raising the funds necessary for the work.

As a result of this action, an adjudication suit has been brought to determine the amounts and priorities of all water rights on Sun River and its tributaries. The State engineer, John W. Wade, has taken charge of necessary surveys of ditches and irrigated lands for use in the adjudication, and has two plane-table parties in the field on the work. A system of measurements of carrying capacity and amount of water used by existing ditches has been carried on during the summer to obtain data for use in the adjudication and to determine the duty of water in this region.

The following form of petition has been circulated among those already owning land within the project:

To the Honorable Secretary of the Interior, Washington, D. C.

SIR: Whereas the United States Reclamation Service, operating under your direction, in accordance with the reclamation act of June 17, 1902, has made a somewhat complete reconnaissance and preliminary survey of the land and irrigation possibilities of the Sun River Valley and lands adjacent thereto in the counties of Cascade, Teton, Chouteau, and Lewis and Clarke, Mont.

And whereas we, the undersigned, being the actual owners or occupants under the laws of the United States of the lands lying in the above-described valley, are fully convinced that irrigation would be of great value to our lands, and are therefore desirous of availing ourselves of the construction of an irrigation system under the terms of the reclamation act;

Resolved, That we respectfully petition that you direct that the detail surveys and computations necessary for an approximate determination of the extent of the proposed system, and the amount of money per acre which must be returned to the reclamation fund in accordance with the provisions of said act, be prosecuted to a conclusion as speedily as is consistent with effective and economical methods.

And further resolved, That we hereby agree, when a project in compliance with said act has been found and declared feasible by you, and when authorized to do so, to form a water users' association under such rules and regulations as you may properly prescribe, and to subscribe for water for the tracts of land described after our names, said tracts of land being specifically shown on the accompanying plat.

——— ——.

——— ——.

Of the private land on the north side 37 per cent had been signed for up to the middle of October. It is expected that by the time the adjudication is completed nearly the whole acreage of private land will be represented upon the petition.

CLARK FORK RECONNAISSANCE.[a]

Clark Fork heads in the Rocky Mountains close to the northeast corner of Yellowstone National Park, in Wyoming, and runs in a general easterly course in Wyoming for about miles, receiving in this stretch several important tributaries, so that when it leaves the canyon it has become a stream of sufficient size, when regulated by some storage, to irrigate 200,000 acres. After leaving the canyon it runs northward until it empties into Yellowstone River at a point 20 miles west of Billings, Mont.

In Wyoming some irrigation has been accomplished by farmers whose lands lie along its banks on either side. In Montana irrigation has been practiced for several years throughout its whole length, approximately all of the lowland lying close to it having been supplied with its water. Most of the canals for watering this lowland have been taken out by the farmers themselves, but some of them have been built by companies.

About fifteen creeks are tributary to Clark Fork throughout its whole length. These streams are dry all the year except during the snow-melting period and the rainy season. They vary in length from 2 to 12 miles, and most of them enter the main stream at right angles. Some of them are steep in grade, particularly near the divide separating the Clark Fork from the Rocky Fork drainage. Along the larger streams in many places are small tracts of land that carry soil of fine quality, which, at a few places where water has been run onto it, is very productive. These tracts are small and are broken by small drainage ways, so that a piece of land 640 acres intact is seldom seen. Long lines of lateral ditches will therefore be required to reach the irrigable areas. The total area available for irrigation may be large, but it is long drawn out.

The general idea of the reconnaissance was to obtain information as to the possibility of diverting water in the vicinity of the canyon, and of taking it across the divide into the Rocky Fork drainage, thus heading all the creeks draining into the fork, and then to again divert it northward from the Rocky Ford onto some of the benches near the Yellowstone River, where the fork empties into it. This reconnaissance is now under way.

During the last days of August, 1905, and the few days following in September, J. A. French, engineer, made a barometric reconnaissance of the locality from the canyon to the junction of the fork with the Yellowstone, with a view of estimating the amount of irriable land and of determining where a diversion might be made in the canyon. The magitude of the scheme and the diversified, broken character of the country prevented an stimate of the land area, while the point of diversion might be at any place within the first 5 miles in the canyon. These facts having been reported to H. N. Savage, supervising ngineer, it was decided that a rough plane-table reconnaissance of the entire area should e made immediately.

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[a] From report by James A. French.

A party under J. A. French began field work on September 7 to obtain an approximate stimate of the length and cost of main canal line, the course of the lines of distribution f water, and the area of first and second class irrigable land that might be served. The ables below show approximately the amount of land available for irrigation on the creeks amed (though more may be reported later) and the approximate length of line of main anal.

Length of canal between specified points on Clark Fork, Montana.

	Feet.
Canal in canyon	32,000
Canyon to State line (Wyoming-Montana)	91,000
State line to Grove Creek	79,000
Grove Creek to South Fork of Bear Creek	40,000
South Fork of Bear Creek to head of Sand Creek	85,000
Total	327,000

Approximate areas in acres irrigable from tributaries of Clark Fork, Montana.

	First class.	Second class.	Total.
Bennett Creek, Wyoming	2,130	3,500	5,630
Line Creek, Wyoming	3,000	1,000	4,000
Tollmans Bench, Montana	1,000	1,080	2,080
Dillworth Creek, Montana	3,500	1,220	4,720
Grove Creek, Montana	4,000	1,680	5,680
Wolf Creek, Montana	500	460	960
Bear and Belfrey creeks, Montana	1,200	560	1,760
Dry Creek (about one-half), Montana	2,200	1,000	3,200
Between Dry and Sand creeks, Montana	1,600	2,000	3,600
Sand Creek, Montana	4,000	2,720	6,720
Total	24,500	13,850	38,350

The reconnaissance so far has discovered considerable land that can be watered, and has shown that a long line of main canal will be necessary through very rough country; that the excavation will be to a considerable extent in rock; that one or two tunnels will be necessary, and that the irrigable land is distributed over a great area and is intercepted by numerous hills and valleys. The water supply, according to measurements made during the past season, is ample. A gaging station will hereafter be maintained on Clark Fork.

The soil that would come under this proposed canal being very productive, a high cost per acre may be expected should sufficient irrigable land be found. The owners of land along the fork will be a unit in favor of the project if it should be found feasible.

CROW RESERVATION PROJECT.

LOCATION.

The lands to be irrigated under the Crow Reservation project (see Pl. XXXII) are in southwestern Montana and lie mostly inside the present limits of the reservation; a large part of them are within the ceded strip which will be opened to settlement under the provisions of the act of Congress approved April 27, 1904. They are adjacent to Yellowstone and Bighorn rivers, and it is proposed to irrigate them by a system depending upon these rivers for the water supply. Their altitude varies from about 2,500 to 3,300 feet above sea level. The principal town and supply point for the region is Billings, which is situated in the Yellowstone Valley on the Northern Pacific Railway at the terminus of the Burlington route. Billings is about 8 miles west of the reservation line. Forsythe, on the Northern Pacific Railway, is a few miles east of the reservation and would be the supply point for the Yellowstone Valley below the mouth of the Bighorn.

LANDS.

Under an act of Congress approved April 27, 1904, the Crow Indians ceded to the United States a strip of land including the northern part of their reservation, embracing about 1,100,000 acres, and the United States agreed to dispose of the land ceded as provided by the reclamation act, the homestead, town site, and mineral-land laws. The Indians on the ceded strip are to have a reasonable time within which to elect whether to remain there or to have their improvements appraised and sold and to remove to the diminished reservation. After the completion of allotments to the Indians, the residue of the ceded lands is to be subject to withdrawal and disposition under the reclamation act, in so far as feasible irrigation projects are found therein; provided, however, that if the lands withdrawn under the terms of the reclamation act are not disposed of within five years, *all of* the lands are to be disposed of as are other lands provided for in the act. In addition to the cost of reclamation the price of these lands is to be $4 per acre when entered under the homestead laws, to be paid as follows: One dollar per acre when entry is made, and the remainder in four equal annual installments, the first to be paid at the end of the second year.

SURVEYS.

During the field season of 1904 preliminary surveys were made of the irrigable lands lying south of Yellowstone River and west of Bighorn River. The result of these surveys was to outline three subprojects for consideration and further investigation.

FORT CUSTER SUBPROJECT.

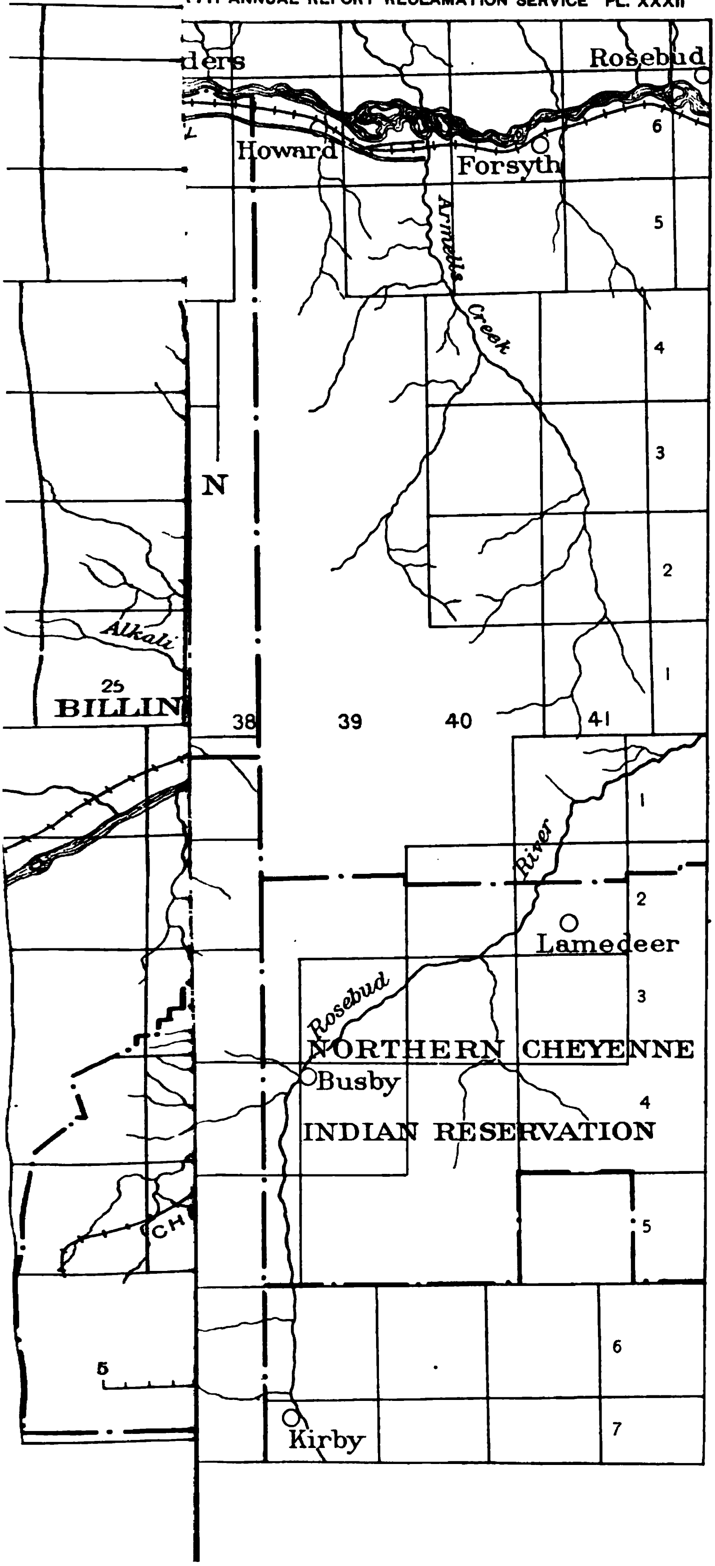
The lands under this project lie on the west side of Bighorn River and extend from the mouth of Two Leggin Creek nearly to the Yellowstone. The Burlington Railroad crosses the irrigable lands at a point opposite the mouth of the Little Bighorn River, and will afford transportation facilities for settlers on these lands. The Northern Pacific Railway passes close to the southern extremity of this project and will do part of the business.

The irrigable lands lie in a rather narrow strip along the river and slope gently back to the foot of a high bench. They stand approximately 3,000 feet above sea level and their soil is rich and can easily be drained. Under the canal there are about 28,000 acres of irrigable land, of which nearly 10,000 acres lie within the limits of the unceded portion of the Crow Indian Reservation and are included within the old Fort Custer Military Reservation. Most of the Indian land has been allotted, and there are a number of old allotments in the ceded portion of the reservation under the Fort Custer canal line.

A careful preliminary survey of a canal line 43 miles long has been made. The topography along this line has been taken by plane table to a scale 200 feet=1 inch. On this basis a paper location of the canal line has been made and quantities have been estimated. The necessary head gates, creek crossings, culverts, etc., have been designed in a substantial and permanent manner and tracings have been prepared for the approval of a consulting board. This project is in such condition that it can be made ready for construction at short notice. Aside from the complications as to allotments, etc., noted above, this project is a very attractive one for early construction.

It has been planned to divert water from Bighorn River by means of a weir, so that all the water may be collected, if necessary, without loss of land. At present the minimum discharge of the river is about 1,500 second-feet, which is over three times the amount actu-

J. S. GEOLO RTH ANNUAL REPORT RECLAMATION SERVICE PL. XXXII



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gaging station on Bighorn River was established at Fort Custer June 16, 1904, and a reful record has since been made of the gage heights. The maximum discharge in 1905 as about 25,000 second-feet.

WACO-SANDERS SUBPROJECT.

This project comprises three tracts adjoining Yellowstone River on the south. The Vaco tract extends from above Waco station, on the Northern Pacific Railway, to Bighorn unnel, just beyond Custer station; a tract near Bighorn station lies at the junction of Big-orn and Yellowstone rivers; the Sanders tract extends from Myers station, on the Northern acific Railway, to Armells Creek, about 6 miles west of Forsythe.

The lands comprised in the tract mentioned above are all of fine quality, those at the ower end being about 2,500 feet above sea level. In the Waco tract there are between ,000 and 5,000 acres, at Bighorn about 1,500 acres, and in the Sanders tract from 13,000 o 23,000 acres, depending on the scheme of irrigation adopted. All the lands are in the eded portion of the Crow Indian Reservation, except about 5,000 acres lying east of the eservation line. There are only a few Indian allotments in the territory.

This project has presented numerous problems and alternatives. A field party now at vork will investigate further the Sanders low-line canal. It is a question whether it is lesirable to provide a gravity system for about 17,000 acres or to resort to power develop-nent and pumping so as to increase this to 23,000 or to 27,000 acres. The Waco ditch an be utilized, at a small relative expense, for the production of power, and it is proposed to use this power in pumping at Bighorn and at Myers station, on the upper end of the Sanders tract.

The water for the Waco and Sanders tracts would be taken from Yellowstone River and for the Bighorn tract from Bighorn River. The supply from either is ample and needs no special discussion. The diversion for the Waco ditch was planned to be at the river bottom, and no provision was made for a weir. The Sanders low line was planned to be handled in the same way.

BIGHORN SUBPROJECT.

This project comprises a large area of high bench lands west of Bighorn River, extending from the mouth of Bighorn Canyon, beyond Peritsa station, on the Burlington Railroad. The strip of lands to be irrigated is about 40 miles long. The map for the Crow Reservation project shows the position of these lands. (Pl. XXXII.)

The irrigable lands under the Bighorn high line are among the finest on the reservation. They are all high, well-drained bench lands, lying at an elevation of about 3,200 feet above sea level, and from 50 to 200 feet above the river. There would be from 40,000 to 50,000 acres under the canal, the amount depending on the exact elevation finally selected for the canal. Somewhat more than half of these lands lie within the boundaries of the diminished Crow Reservation. For this reason, and also because the cost of development is somewhat high, it is probable that some years may elapse before the project could be built.

In order to cover the bench lands comprised in the Bighorn project a high diversion dam at the mouth of Bighorn Canyon will be necessary. The dam would abut against solid limestone on both sides and the foundation would probably be of the same material. Two sets of soundings have been taken, but no borings have been made. A rough estimate has been made for a dam 145 feet high from a foundation 15 feet below the bottom of the river bed. This dam would be about 130 feet long at the low-water surface of the river, 232 feet long at a point 80 feet above the river bed, and about 650 feet long on top. The canal line recommended would have siphons at Beauvais Creek and at Woody Creek, and a drop of about 100 feet at Two Leggin Creek. This drop and the high dam would both furnish a large amount of power, which could possibly be used for pumping.

As previously mentioned, it is planned to take the water for this project from Bighorn River by means of a high diverting dam. At present there is just about enough water at low stage to satisfy the requirements of this project, the Fort Custer project, and the Indian ditch on the east side of the river, which covers about 30,000 acres. When the Shoshone project and private ditches planned are built in Wyoming it is probable that the discharge of the Bighorn will be materially decreased, and it is thought that the diversion dam at the mouth of Bighorn Canyon could be increased in height to provide for the required amount of storage. A diversion dam and canal line 45 feet lower than the one estimated has been recommended, and it would be quite feasible to leave the dam alone and use the additional 45 feet, or so much of it as may be needed, for storage purposes.

LAKE BASIN PROJECT.[a]

The lands to be irrigated under the Lake basin project (see Pl. XXXIII) are in Yellowstone and Sweet Grass counties, in a tract between Billings and Greycliff running back 35 or 40 miles northward from Yellowstone River. The two main bodies of irrigable land are the "Lake basin," containing about 100,000 acres, in Tps. 1 to 3 N., Rs. 19 to 22 E., at elevations ranging from about 3,900 to about 4,200 feet, and the "Twentymile basin," containing about 75,000 acres, in Tps. 3 and 4 N., Rs. 22, 23, and 24 E., at elevations ranging approximately from 3,700 to 4,000 feet. Other smaller tracts may perhaps bring the total up to 250,000 acres or more.

During the field season of 1905 reconnaissance surveys are being made (1) to determine roughly the amount of irrigable land and (2) to run a line to show roughly the length and position of the canal that may be necessary.

The latter survey has so far shown that in order to get water into the Lake basin at an elevation of 4,200 feet it will be necessary to construct a canal heading probably between Big Timber and Livingston and running for about 200 miles along the southern slope of the Sweet Grass divide. Much of this distance will be rock work and there is a considerable amount of cross drainage. There is some possibility that by raising the line about 400 feet a tunnel may be made from a branch of Sweet Grass Creek through the divide into the Lake basin. After getting around the end of the Sweet Grass divide the line runs for about [illegible] miles around the Lake basin and a smaller basin on its northern side, known as the Haik[illegible] basin—in which it may be possible to provide storage—leaves this basin by a tunnel, and in about 7 miles enters the Twentymile basin, continuing about 45 miles around that basin and dropping about 300 feet near its northern end.

The railroad land in this area is now all in private ownership. But very little public land has been taken up.

MADISON RIVER PROJECT.[a]

GENERAL DESCRIPTION.

A number of tracts of irrigable land lie along Madison and Missouri rivers in western Montana, comprising a total of about 175,000 acres of first-class land, 50,000 acres of second-class land, and 12,000 acres of third-class land. A rough preliminary reconnaissance of these tracts was made in 1904, which determined in a general way the areas to be considered and some of the important elevations and conditions to be provided for, and surveys and investigations have been undertaken during the field season of 1905 to determine the feasibility of irrigating the lands.

The project in general (see Pl. XXXIV) depends on the feasibility of constructing a gravity canal to divert water from Madison River near the mouth of Madison River Canyon. The water in this canal must be siphoned across Jefferson River. Alternative locations for this structure have been determined and the better one will be selected when detailed estimates are made. In addition to the siphon the surveyed line involves tunnels at Crow Creek divide and Milligans Gap and shorter tunnels at other points, as well as a great deal of

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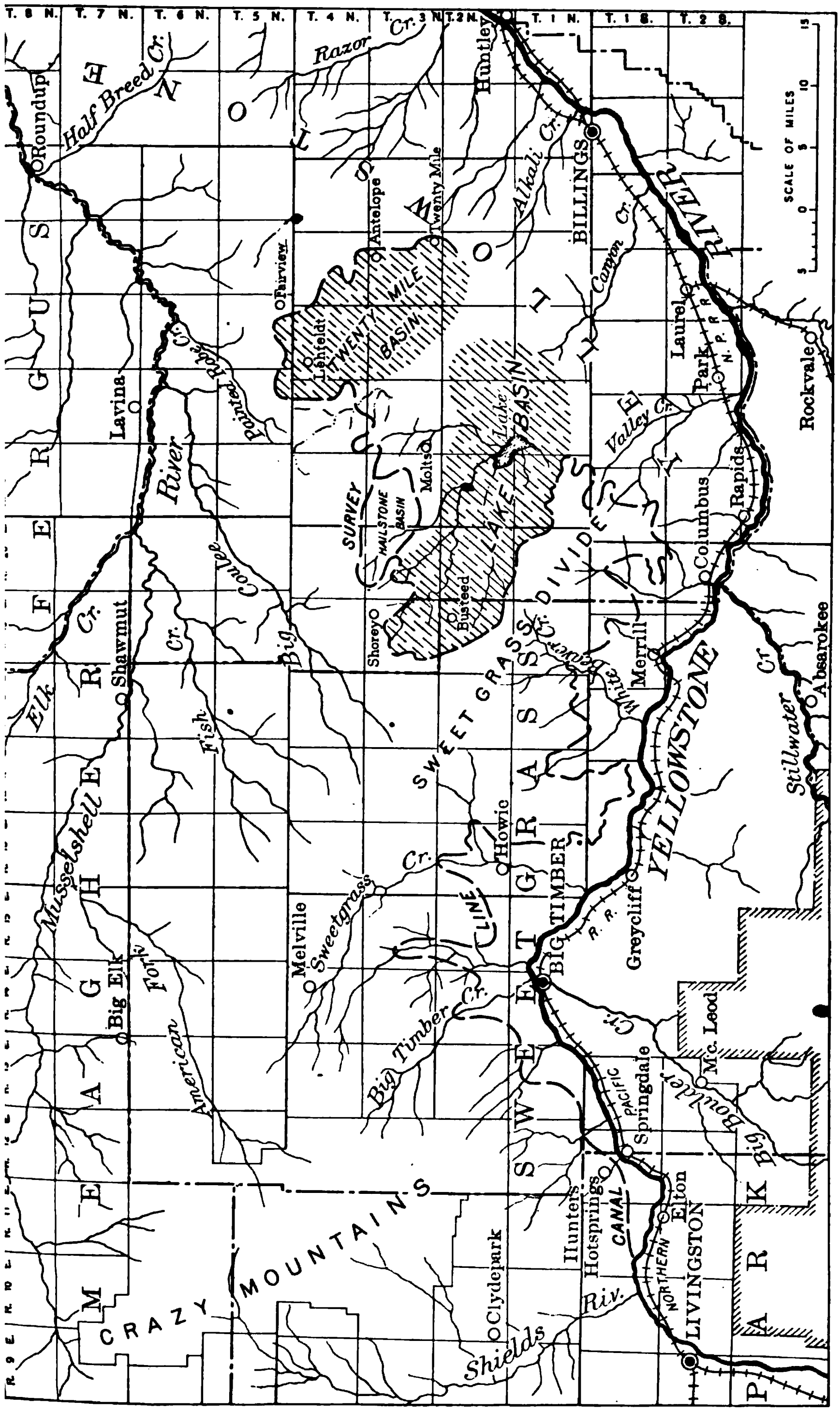
[a] From report by George E. Stratton.



GENERAL MAP OF PROPOSED LAKE BASIN PROJECT, MONTANA.

expensive rock work on hillsides. To reach the Prickly Pear Valley this line as surveyed would be about 150 miles long. A second canal line, called the Townsend canal line, has been surveyed from a diversion point 3 miles above Toston, on the Missouri River, nearly to Canyon Ferry, to cover lands on the east side of Missouri River.

Owing to the appropriation of water from Madison and Missouri rivers for water power and other purposes, the supply for irrigation on a large scale must be increased by extensive storage of the flood waters of Madison River. Surveys for a dam in Madison Canyon and for a reservoir site in upper Madison Valley have been made.

LANDS.

The lands have been outlined by means of topographic surveys and traverse lines. In this way the acreages have been determined and will be mapped. The lands lie at elevations ranging approximately from 3,750 to 4,400 feet above sea level. The classification was made at the same time as the surveys by general inspection of the nature of the soil, including observations as to its freedom from alkali and stones. First-class land is practically free from alkali or stones, and lies well for irrigation. Second-class land has some alkali or stones and may be more or less broken. Third-class land is rough, contains considerable alkali, is poor and stony, or is a combination of these. A considerable portion of the lands is in private ownership, but the amount so held can not be determined until the map has been completed.

The following table gives, in acres, the main bodies of land:

Land under Madison River project.

	First class.	Second class.	Third class.
The Prickly Pear Valley (elevation, 3,750 to 4,000 feet), near Helena	44,000	15,000	1,600
Winston Slope (elevation 3,800 to 4,300 feet)	11,000	12,000	9,000
Crow Creek Valley (elevation 3,900 to 4,400 feet)	46,000	16,000	1,500
South of Crow Creek Divide	38,000	10,000	....
East of the Missouri River (after deducting 14,000 acres now irrigated)	35,000	2,400	....
Total	174,000	49,400	12,100

The following lands have been withdrawn from entry by the honorable Secretary of the Interior, by letter dated February 7, 1905, excepting any tracts the title to which has passed from the United States:

Land comprised under first form of withdrawal.

[Montana principal meridian.]

Township.	Range.	Section.
1 S.	1 E.	1,4-8,12,13,17-20,24,25,30,36.
2 S.	1 E.	1,12,13,24,25,34,35,36.
3 S.	1 E.	2,3,9,10,11,15,16,21,22,27,28,33,34.
1 S.	2 E.	6,7,18,19,30,31.
2 S.	2 E.	6,7,18,19,30.
1 S.	1 W.	1-4, 12, 13, 24, 25.
1 N.	1 E.	25-29,32-36.
1 N.	2 E.	30,31.
1 N	1 W.	1,2,10,11,12-17,20-29,32-36.
2 N.	1 W.	1,2,11-15,22-26,35,36.

Land comprised under second form of withdrawal.

[Montana principal meridian.]

Township.	Range.	Section
1 N.	1 E.	1-24, 30, 31.
2, 3, 4, 5 N.	1 E.	All sections.
6 N.	1 E.	1-3, 12, 13, 24-36.
7 N.	1 E.	1-5, 8-17, 21-28, 34-36.
8, 9 N.	1 E.	All sections.
1 N.	2 E.	5-8, 17-20, 29, 32.
2 N.	2 E.	3-8, 17-21, 30-32.
3 N.	2 E.	1-24, 27-34.
4 N.	2 E.	All sections.
5 N.	2 E.	4-10, 14-23, 26-36.
6 N.	2 E.	6-8, 16-21, 28-33.
7 N.	2 E.	6, 7, 18, 19.
4 N.	1 W.	1, 2, 11-14, 23-26, 35, 36.
8 N.	1 W.	1, 2, 11, 12.
9 N.	1 W.	1-18, 22-27, 34-36.

SURVEYS.

During the field season of 1905 preliminary surveys of the different main canal lines and irrigable lands have been carried on. Besides the lines of the Madison River main canal and the Townsend canal, shown on the accompanying map (Pl. XXXIV), a number of alternative and reconnaissance lines have been run and a general reconnaissance has been made of Madison and Jefferson rivers. These surveys will furnish data for an estimate of the cost of the canal lines examined. The following elevations of controlling points on the main canal line have been determined, the point of diversion being limited to places below Cottonwood Gulch by the existence of a power plant in the canyon above:

Elevations of controlling points on main canal line, Madison River project.

	Feet.
Madison River at diversion near Cottonwood Gulch	4,510
Jefferson River at lower canyon near Sappington	4,160
Milligans Gulch divide	4,634
Crow Creek divide	4,519
Winston Pass	4,361

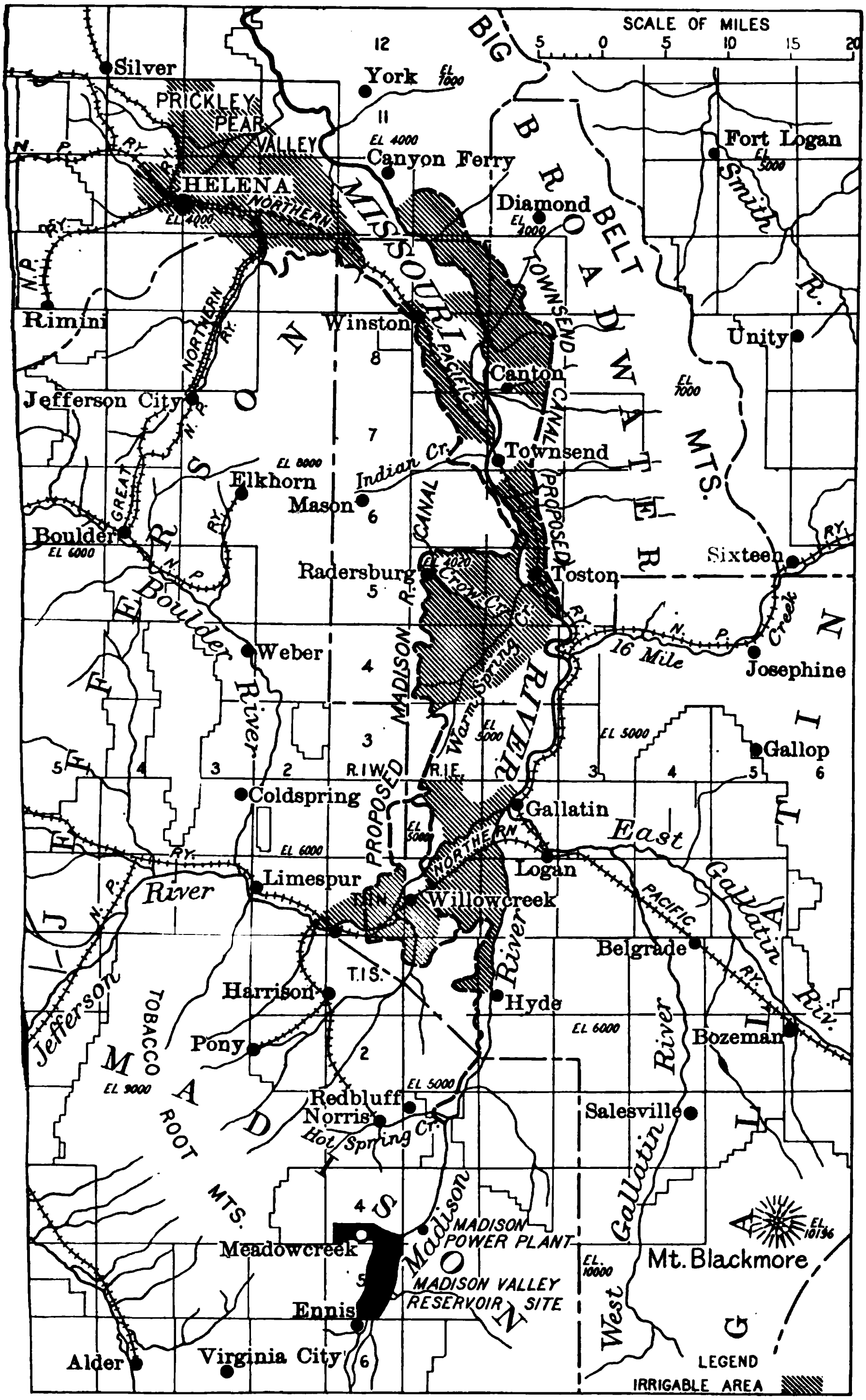
Two sites for crossing Jefferson River have been examined, one at the lower canyon near Sappington, requiring a siphon about 11,000 feet long, the other below Willow Creek, requiring about 18,000 feet of siphon.

WATER SUPPLY.

The discharge of Madison River is given by the records at the gaging station below Red Bluff. There is a gaging station on the Jefferson at Sappington, on the Gallatin at Logan, and on the Missouri at Cascade. A study of these records will enable the amount of storage water available to be determined.

Power plants on the Missouri River at Canyon Ferry and lower down now find the low-water flow of that river insufficient. There are also a considerable number of small private ditches taking water from the Missouri and Madison rivers.

A power company has provided some storage by a dam in the Madison River Canyon, forming a reservoir in the basin above. It may be possible to increase the height of this dam and thereby provide a considerable amount of storage.



GENERAL MAP OF PROPOSED MADISON RIVER PROJECT, MONTANA.

OPERATIONS IN NEBRASKA.

By Charles E. Wells.

NORTH PLATTE PROJECT.

Prior to 1904 investigations had been begun on the North Platte project and considerable progress had been made in work leading to the irrigation of lands in the valley of the North Platte. As the work proceeded it became apparent that, in order to reclaim any considerable area, storage must be provided. The flow of the North Platte at the Wyoming-Nebraska line was found to be so small that there was already a scarcity of water when the river was low, and the securing of adequate storage was therefore a matter of the utmost importance. Investigations of the Sweetwater reservoir had proved its impracticability on account of the shortage of water. The Pathfinder reservoir site, however, lying in the valley of the North Platte at its junction with the Sweetwater, was found to be adequate. Surveys had been made of the valley and of the dam site and the conditions in both were found to be exceptionally favorable. As has already been reported, the capacity will exceed 1,000,000 acre-feet and the cost will be scarcely more than $1 per acre-foot, the reservoir being capable of controlling all the surplus flow of the river for the entire year. unless the discharge be exceptionally large.

The dam is located in a solid-rock box canyon 3 miles below the mouth of the Sweetwater. At the point selected for the dam the canyon varies in width from 60 feet at the bottom to 160 feet at the top; its extreme height from bed rock is about 200 feet. Diamond-drill borings made in 1903 show perfect foundations of granite.

The necessary storage having been provided, the next step was to find land on which water could be used and, contrary to expectation and popular belief, this proved to be far the most serious and difficult problem. The fall of the North Platte is from 4 to 6 feet per mile. It flows in Wyoming through a channel bordered by very narrow and small areas of bottom land, from which the hills rise abruptly at a height of from 100 to 500 feet, necessitating long and expensive canals.

SWEETWATER VALLEY CANALS.

No work has been done during the past year in the Sweetwater Valley, and for the present no investigations will be made on this part of the work.

ALCOVA-CASPER CANAL.

In a further effort to secure land for reclamation as high up on the stream as possible, a line was run from Alcova, about 8 miles below the Pathfinder reservoir, to a point about 8 miles north of Casper.

The project contemplated a 50-foot dam at Alcova, and the canal was to be extended indefinitely eastward to cover lands on the north side of the divide between North Platte River and the tributaries of the Missouri as well as lands in the valley of the North Platte.

The canal to the point south of Caspar would have a length of about 80 miles. It would traverse country in which construction would be very expensive and maintenance uncertain and costly. For miles it would skirt shale and gypsum hills, cross deep arroyos, and penetrate narrow adobe or shale ridges. The results of the surveys were as follows:

Land under Alcova-Casper canal project.

	Acres.
Amount of land under canal	40,00
Amount of irrigable land	30,00

On the recommendation of the district engineer the board of consulting engineers ordered that nothing more be done at present on this project.

CASPER-DOUGLAS CANAL.

SOUTH SIDE.

The Casper-Douglas canal extends from a point about 8 miles above Casper, on the south side of the river, nearly to Inez. A preliminary survey to ascertain the probable amount of land that could be covered was made in June and July, 1904.

A canal 60 miles long would cover all the irrigable land on the first bench above the river, the greater acreage being in small valleys on the tributary streams. The area covered would be about 25,000 acres. It is possible to enlarge the project considerably by extending it to the Fetterman Flats and by irrigating the lands at Careyhurst. The latter now have a sufficient supply from Boxelder Creek, but if all the land under the proposed canal were irrigated from Boxelder Creek the released water could be used on land higher up on the Boxelder and an equal amount of land now desert could be reclaimed.

Nearly all the land is in private ownership, and much is held in large tracts, notably the Careyhurst lands and the Fetterman Flats. It is probable that a cooperate plan can be worked out by the owners of the land; or, in the hands of a water-users' association, the project could be made feasible by bringing all the private lands into the project.

During 1905 no work was done on the Casper canal, the efforts of the engineers having been confined to those projects which appeared more favorable and more feasible.

NORTH SIDE.

The north-side canal was surveyed late in the fall of 1903 by A. J. Parshall. Lines had been previously run by Elwood Mead and W. D. Pease. Wooden flumes and works of cheaper and less permanent character than would be put in by the Government were contemplated. The area covered is more than 25,000 acres, much of which, however, is rough and not irrigable. Probably there are between 15,000 and 20,000 acres of good land.

Most of the land under this canal is in private ownership. Further surveys and examinations on both the north and the south canal are intended, but before these are made the people of the district should indicate whether or not they desire the work to be done and what proportion of the land held in private ownership will be subscribed.

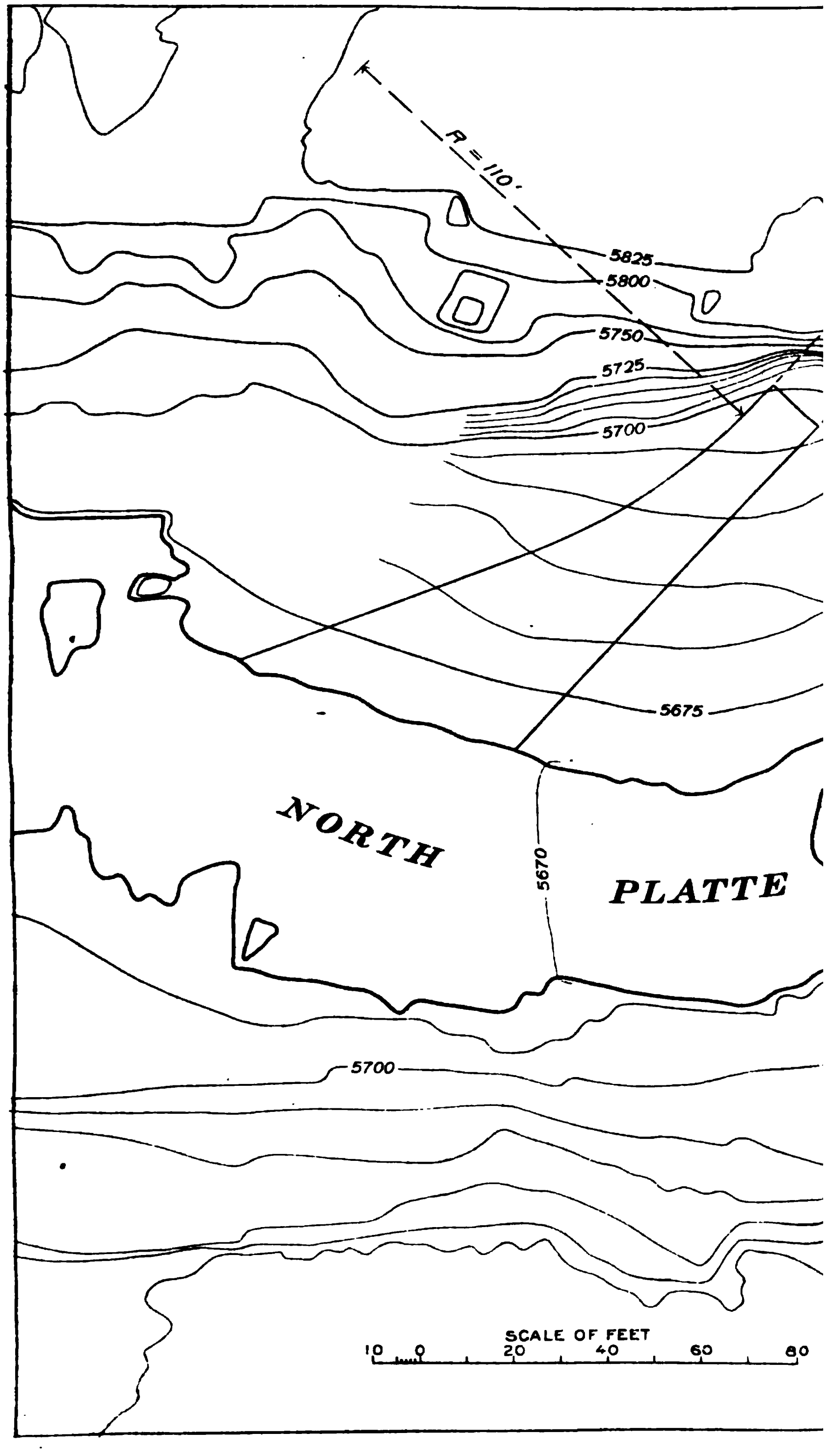
GOSHEN HOLE CANAL.

At Goshen Hole the entire season of 1903 was consumed in making preliminary locations and gathering data for preliminary estimates.

The canal would be about 140 miles long, of which about 6 miles would be tunnel. Many reservoir sites along the line could be easily developed and would be of great utility to the system. There are about 150,000 acres of irrigable land under the canal, probably 10,000 more which can be reached by pumping, and 5,000 more which lie under a short canal on the north side of the river at Guernsey. The lift would not be great and the power could be economically generated at the diversion dam at Guernsey. This diversion dam will necessarily be rather expensive, being 125 feet long at low water and about 1,400 feet long at its crest.

The land in Goshen Hole is of good quality, though somewhat rolling and in places broken. On October 1, 1904, borings with diamond drill were begun. Topographic surveys of the upper 6 miles of the canal were made in the spring of 1904.

U. S. GEOLOGICAL SURVEY



No work was done on the Goshen Hole canal during 1905 except boring for foundations in he vicinity of Guernsey. This work showed that the foundation for the proposed dam robably exceeded 90 feet below the present surface, and that it would be impracticable to onstruct a masonry dam at this point. The borings extended from Fairbanks to a point bout 3 miles upstream. Bed rock was not reached at any point, though none of the holes rilled were less than 75 feet deep. It will probably be necessary to construct a heavy rock-ill dam at Fairbanks, material for which can be obtained at a low cost. The material proposed to be used consists of the waste from the iron mines at Sunrise. It is proposed, during he coming winter, to take up the consideration of this dam, and plans have been prepared for submission to the board of consulting engineers in the fall of 1906. Judging from the prices obtained for work on the interstate canal, it is probable that the first estimates of the cost of the Goshen Hole canal were high. The project, however, depends on the feasibility of erecting a rock-fill dam at Fairbanks.

FORT LARAMIE CANAL.

During the summer of 1904 a preliminary line was run on the south side of the North Platte River, in Laramie County, Wyo., beginning about 8 miles west of old Fort Laramie, at the point where the proposed interstate canal will head but on the opposite side of the river.

The land under the Fort Laramie canal, as shown by the preliminary survey, embraces nearly 50,000 acres, about equally divided between Wyoming and Nebraska. The line as run was about 120 miles in length and ended at a point about 5 miles east of Gering, Nebr. The land covered, especially that in Nebraska, is of the best quality.

With reference to this canal two propositions present themselves—whether it would be more economical to build the Goshen Hole canal with a capacity sufficient to irrigate the 50,000 acres under the Fort Laramie canal or to make the Goshen Hole canal smaller and to irrigate the 50,000 acres from a lower line canal, such as the Fort Laramie. One of these two courses will probably be adopted. If, however, the cost of construction of the Goshen Hole canal proves prohibitive, the information at hand seems to indicate that the Fort Laramie canal can be constructed with a reasonable expenditure.

During 1905 the matter of the construction of the Fort Laramie canal was taken up by the citizens in the vicinity of Gering, especially by those having land under the Gering canal. About 16,000 acres of land are now receiving water from the Gering canal. The maintenance charges, however, are very high, and as the district is heavily bonded the water users, in view of the great cost of maintenance, the uncertainty of obtaining a supply of water, and the desire to increase the irrigable area by bringing under cultivation the lands above the Gering canal, have indicated their willingness to enter into contract with the Secretary of the Interior for a supplemental supply of water for their lands. It is estimated that about $250,000 will be derived from this source, which will materially aid the Government in its effort to irrigate lands under the proposed Fort Laramie canal. It is possible that other canals and other water users will require water from the Fort Laramie canal, in which case the probability of the construction of the canal is greatly increased.

PATHFINDER DAM.

Bids for the construction of the Pathfinder dam (Pl. XXXV and XXXVII) and auxiliary works were opened at Denver, Colo., June 15, 1905, and a contract for the work was subsequently awarded to Bradbury & O'Gara, of Denver, Colo., who declined to enter into a contract with the Secretary of the Interior. The work was readvertised and bids were opened at Denver, August 16, 1905. There were six bidders. As the lowest bidder was not thought to have the equipment and experience necessary for so important a work, the contract was awarded September 1, 1905, to The Geddes & Seerie Stone Company, of Denver, Colo., the second lowest bidders, at $482,000. The contract was promptly signed and work on the excavations was begun Septemper 25, 1905.

An abstract of the bids received is given below:

Bids received for the construction of the Pathfinder dam, North Platte project.

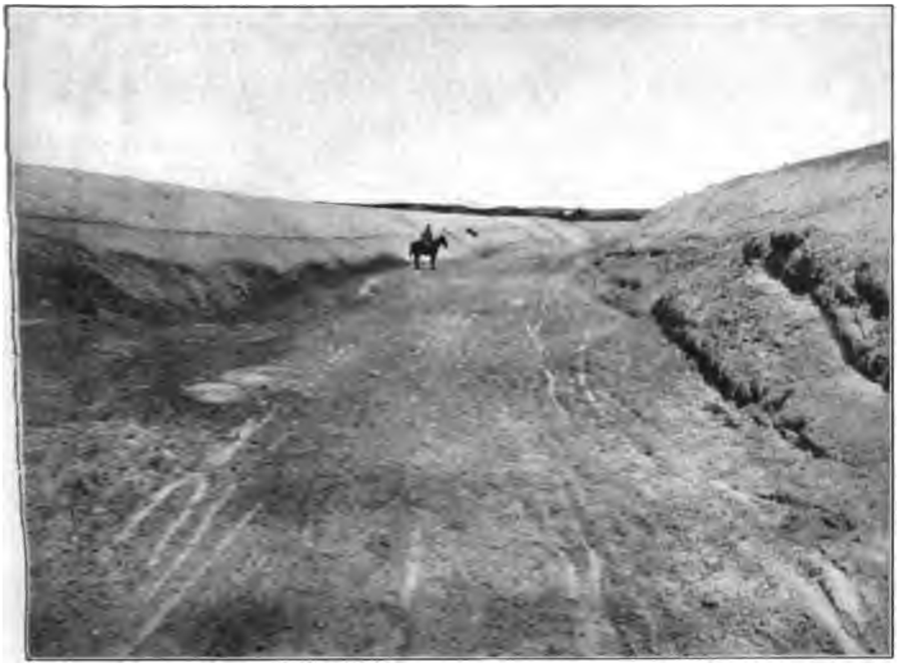
Description of work.	Quantity.	N. S. Sherman, Oklahoma City, Okla.		Geddes & Searle Stone Co., 611 Continental Building, Denver, Colo.		Kilpatrick Br & Collins Con-tracting C, Beatrice, Nebr	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amoun
Masonry:	*Cub. yds.*						
Portion of dam above elevation 5,660, including bastions and guide walls.	50,000	$6.00	$300,000.00	$6.25	$312,500.00	$6.80	$340,00
Portion of dam below elevation 5,660	3,000	8.40	25,200.00	9.00	27,000.00	15.00	45,00
Excavation for foundation of dam and spillways:							
Class 1	2,500	1.40	3,500.00	2.00	5,000.00	5.00	12,50
Class 2	500	5.60	2,800.00	6.00	3,000.00	10.00	5,00
Class 3	2,000	2.10	4,200.00	4.00	8,000.00	3.00	6,000
Concrete in bridges, towers, spillways, and guide walls	1,000	7.56	7,560.00	6.50	6,500.00	7.50	7,50
Hauling cement from Casper to dam site	*Barrels.* 40,000	2.90	116,000.00	3.00	120,000.00	3.25	130,00
Total			[a]459,260.00		[b]482,000.00		546,00

Description of work.	Quantity.	Wyttenbach & Dunnegan, Sturgis, S. Dak.		J. G. White Co. (Incorporated), 43 Exchange place, New York City, N. Y.		The Keltie St Co., Joliet, Ill.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amoun
Masonry:	*Cub. yds.*						
Portion of dam above elevation 5,660, including bastions and guide walls.	50,000	$7.50	$375,000.00	$7.50	$375,000.00	$8.35	$417,500.00
Portion of dam below elevation 5,660	3,000	10.40	31,200.00	8.00	24,000.00	8.65	25,950.00
Excavation for foundation of dam and spillways:							
Class 1	2,500	2.50	6,250.00	2.25	5,625.00	1.21	3,025.00
Class 2	500	6.00	3,000.00	18.00	9,000.00	3.00	1,500.00
Class 3	2,000	3.00	6,000.00	4.50	9,000.00	2.50	5,000.00
Concrete in bridges, towers, spillways, and guide walls	1,000	7.00	7,000.00	12.00	12,000.00	4.75	4,750.00
Hauling cement from Casper to dam site	*Barrels.* 40,000	3.00	120,000.00	2.99	119,600.00	3.00	120,000.00
Total			[c]548,450.00		[a]554,225.00		[a]577,725.00

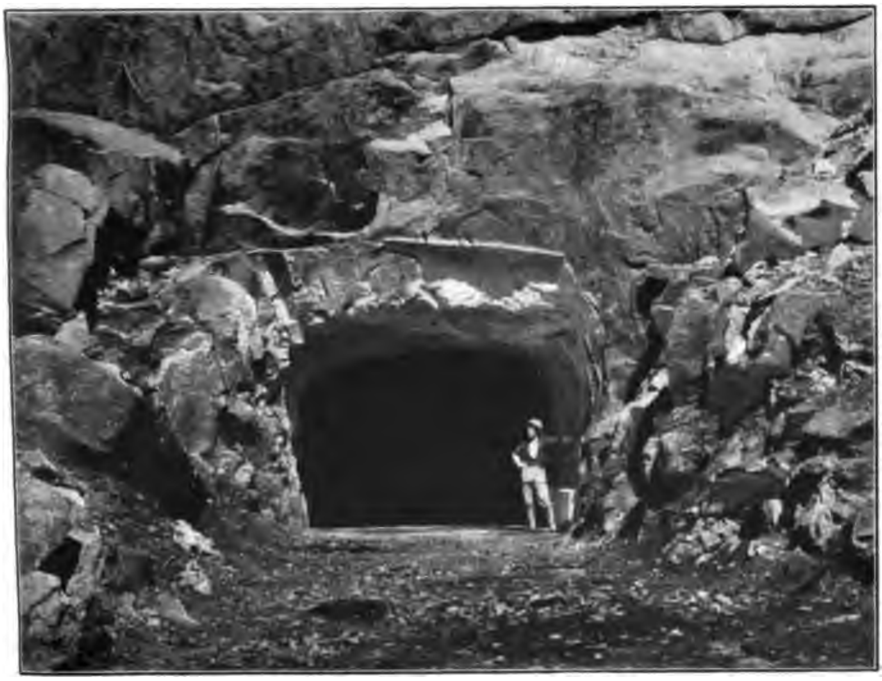
[a] Entire work, or none.

[b] Entire contract.

[c] All of schedule.



A. PARTLY COMPLETED PORTION OF THE INTERSTATE CANAL, NORTH PLATTE PROJECT, WYOMING.



B. TUNNEL, PATHFINDER DAM, NORTH PLATTE PROJECT, WYOMING.

PATHFINDER TUNNEL.

Bids for the construction of the diversion tunnel were opened January 9, 1905, and the contract awarded to Kilpatrick Bros. & Collins Contracting Company, of Beatrice, Nebr., the basis of award being $34,292.50. The agreement was signed February 10, 1905. The bids were as follows:

Abstract of bids for Pathfinder tunnel.

	Kilpatrick Bros. & Collins Contracting Co., Beatrice, Nebr.		Faris-Kesl Construction Co. (Limited), Boise, Idaho.		Streeter & Lusk, Denver, Colo.		McDonough & Meehan, engineering contractors, Chicago, Ill.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Approaches, solid rock, 1,000 cubic yards	$1.25	$1,250.00	$2.00	$2,000.00	$1.25	$1,250.00	$2.00	$2,000.00
Loose material, 2,500 cubic yards	.60	1,500.00	1.00	2,500.00	.60	1,500.00	1.00	2,500.00
Tunnel 480 linear feet	38.00	18,240.00	45.00	21,600.00	57.00	27,360.00	49.00	23,520.00
Shafts, 350 linear feet	38.00	13,300.00	33.00	11,550.00	57.00	19,950.00	140.00	49,000.00
Overhaul, 100 cubic yards per 100 feet	.025	2.50	.02	2.00	......	....	.20	20.00
Total	....	34,292.50	....	37,652.00	....	50,060.00	....	77,040.00

Electric drills mounted on columns were used in the tunnel, which was driven from each portal and taken out full size. Work on the shafts was begun with hand drills, which were supplanted by steam drills and these in turn by electric drills. Operations in the tunnel were suspended from May 23 to July 4 because of high water in the river. As soon as the water subsided the concrete lining was put in place. The contract was completed August 15, 1905, at a cost of $33,259.75. The portal of the tunnel is shown on Pl. XXXVI, *B*.

PATHFINDER RESERVOIR.

Negotiations are in progress for the purchase of private land which will be overflowed by the reservoir and agreements have been made with several owners for the sale of their land to the Government.

PILE BRIDGE ACROSS NORTH PLATTE RIVER.

Bids were opened at Casper, Wyo., June 29, 1905, for the construction of a pile bridge across the North Platte River, about 25 miles southwest of Casper. This bridge is to be used in connection with the construction of the Pathfinder dam. The contract was awarded to J. F. Stanley, of Casper, Wyo., the lowest bidder, at $3,384.70, work to be completed September 17, 1905. Immediately after the award of the contract, Mr. Stanley ordered material for the work, and the piles were promptly delivered at the bridge site. Owing to a telegraph operators' strike on the Northern Pacific Railroad the work was delayed and an extension of time of sixty days was granted the contractor. The contract was completed October 21, 1905, at a cost of $3,114.98.

ENGINEER'S CAMP AT DAM SITE.

A permanent camp has been completed for the use of the engineers in charge of construction at the Pathfinder dam site and is now occupied.

Larger office accommodations have been secured at Casper, Wyo., and headquarters established there.

INTERSTATE CANAL.[a]

The area under the Interstate canal (Pl. XXXVIII) may amount to 238,000 acres, but as stated before, much of this land can be served by other canals. Division according to such service gives the results shown in the following table:

Acreage of lands under interstate canal classified by their positions under other canals.

Lands under—	Minimum.	Probable amount.	Maxim
Interstate canal only:			
Government	80,000	80,000	100,00
Private	10,000	20,000	30,00
Whalen Falls canal:			
Carey act	10,000	10,000	14,00
Private	10,000	10,000	14,00
Farmers' canal:			
Controlled by sugar company	....	....	30,00
Private	....	30,000	30,00
Other canals	....	10,000	20,00
Total acreage	110,000	160,000	238,00

Seventy per cent of these lands are first-class, and the remaining 30 per cent are almost entirely second-class. Practically no third-class land is embraced in the 110,000 acres estimated, all high, worthless, and badly broken land having been excluded as far as possible.

Whalen Falls canal was built and promoted primarily to irrigate about 14,000 acres of land lying mostly on the east side of Rawhide Creek, under the Carey act; and, secondarily, to irrigate about an equal amount in private ownership, nearly all of which lies west of Rawhide Creek. The canal has been constructed in a temporary manner.

The first 50 miles of the Interstate canal lies upon the right of way of the Whalen Falls canal, belonging to the North Platte Canal and Colonization Company. Contract providing for the use of this right of way and authorizing the United States to enlarge the 20 miles of the canal already constructed was approved by the Secretary of the Interior December 22, 1904. Among other conditions it was agreed that the United States would carry the water to which the North Platte Canal and Colonization Company was entitled, as the same may be flowing in the river, exclusive of stored water, and that water would be delivered for irrigation to the lands under control of the company "in time for beneficial use during the irrigation season of the year 1906."

The contract for the construction of the Interstate canal was drawn with the view that the canal could furnish water in time for beneficial use within the irrigation season of 1906, as an attempt to complete the canal by the beginning of the season would have involved considerable expense. The company, however, has claimed that the water should be delivered in the early part of the season and the Department has adopted this view of the contract. Negotiations are now under way to provide for completion of the canal by the beginning of the irrigation season.

The construction of the Farmers' canal was begun many years ago. It was completed to Spotted Tail Creek, just north of Mitchell, Nebr. The canal heads just east of the Nebraska-Wyoming State line, and, as completed, is about 20 miles in length. Its original capacity was probably 600 second-feet, but its present capacity is probably not more than one-third of that amount.

About 1893 financial difficulties overtook the company and construction was suspended. It has not been resumed, and until recently the abandonment of the extension was generally conceded. Some months ago a petition was circulated among the owners of land under the uncompleted portion of the Farmers' canal, asking the Government to construct

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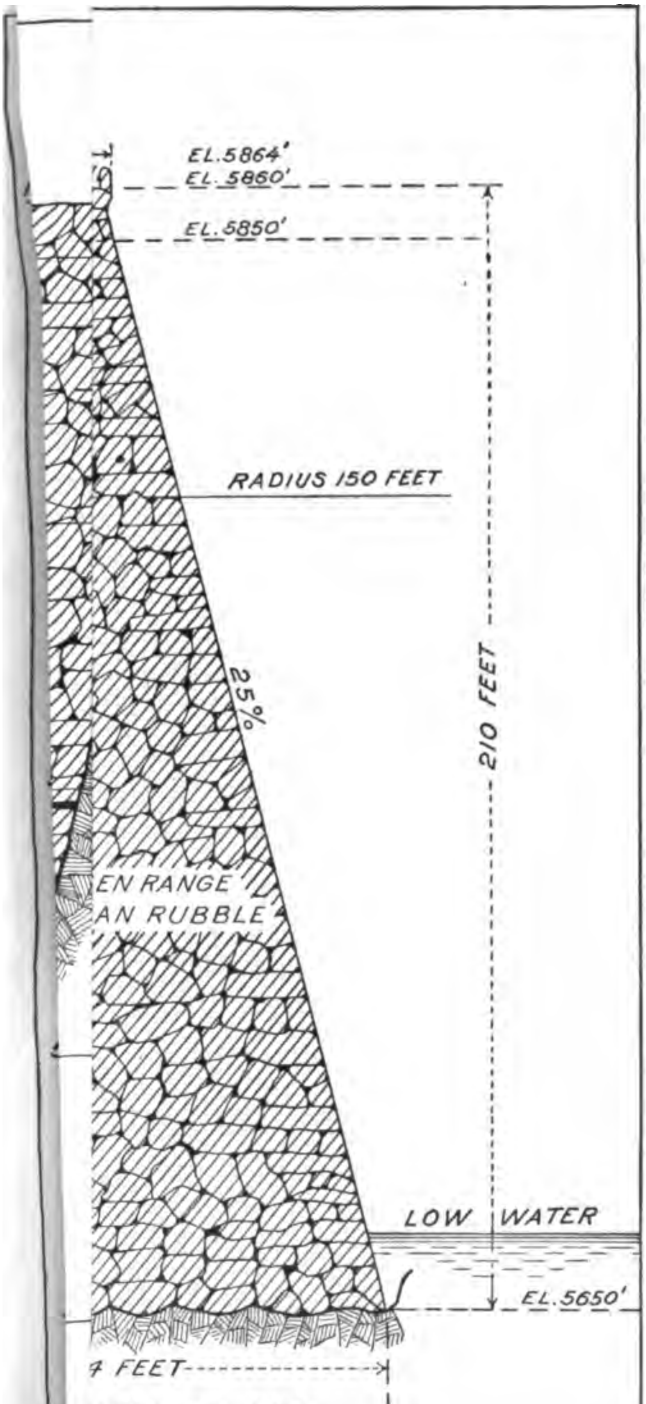
[a] From report by John E. Field.


S.L.
EL.5864'
EL.5860'
EL.5850'
RADIUS 150 FEET
25%
210 FEET
EN RANGE
AN RUBBLE
LOW WATER
EL.5650'
4 FEET

CTION OF DAM

the interstate canal of sufficient capacity to irrigate these lands. The amount of land represented by these petitioners was about 30,000 acres.

The headworks of the Interstate canal will be a diversion dam from 6 to 10 feet above the bed of the river and from 300 to 350 feet in length. Its exact location has not yet been determined. Borings will be made in the near future to determine this point.

The first 20 miles of canal involve rather difficult construction, but after these are passed few difficulties will be encountered, the most serious occurring at a point where the canal must be carried about 1 mile through sand hills. The greatest obstacle there, however, is not in construction but in loss by seepage. For almost the entire distance the excavation will be in earth. Little sidehill work will be encountered, and the cost should be rather low for so large a canal. There are numerous reservoir sites along the line of canal, which will simplify the matter of seepage and the maximum demand upon the canal during the latter part of June and early part of July.

The topographic surveys made during 1904 covered about 110,000 acres, 75,000 of which were classified as irrigable land. During 1905 topographic surveys were continued, 132,640 acres having been mapped. About 70 per cent of the land in this tract will be irrigable. The two seasons' work, therefore, indicate that of the 242,640 acres surveyed about 165,000 acres will be irrigable. It must be remembered, however, that about 80,000 acres of this land is under existing canals or proposed extensions of the same, as indicated in the foregoing tabulation, one-half of which may not be irrigated from the canal.

The lateral system, contracts for which will be let early in the spring of 1906, will complete the system for the first 75 miles. About 30,000 acres should therefore be irrigated during the season of 1907.

The first contract for the Interstate canal was let for work as follows: Divisions 1, 2, 6, 7, 9, and 10, Robinson & Maney, St. Louis, Mo., the total estimated cost being $216,368; division 3, Griffiths & McDermott, Chicago, Ill., $78,135; division 4, Deadwood Construction Company, Deadwood, S. Dak., $32,695; division 5, Orman & Crook, Pueblo, Colo., $76,647; division 8, James O'Connor, Morgantown, Ind., $37,560. Work is being diligently prosecuted on divisions 1 to 6 inclusive and also on division 8.

Bids for the structures and for the second 50 miles of the canal were opened November 8. Abstracts of all the bids are given below:

Bids for first contract, Interstate canal, North Platte project.

Division.	Work.	Quantity in cubic yards.	Orman & Crook,, Pueblo, Colo., ten $2,000 cash checks.[a]		Griffith & McDermott, 1011 Merchants' Loan & Trust Building, Chicago. Ill., one $20,000 check.[a]		Robinson & Maney, 1609 Chemical Building, St. Louis, Mo., one $9,000 certified check, one $1,000 cash check, five $2,000 cash checks.[b]	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
1	Excavation:							
	Class 1	260,000	$0.13¼	$34,450.00	$0.15	$39,000.00	$0.11.99	$31,174.00
	Class 2	10,000	.40	4,000.00	.50	5,000.00	.60	6,000.00
	Class 3	100	.35	35.00	.35	35.00	.75	75.00
	Class 4	1,500	.77	1,155.00	.65	975.00	.80	1,200.00
	Overhaul	140,000	.01¾	2,450.00	.01¼	1,750.00	.01	1,400.00
	Puddle	1,000	.40	400.00	.75	750.00	.75	750.00
	Total			42,490.00		47,510.00		40,599.00
2	Excavation:							
	Class 1	330,000	.12¾	42,075.00	.12	39,600.00	.11.99	39,567.00
	Class 2	100	.46	40.00	.50	50.00	.60	60.00
	Class 3	100	.35	.35.00	.35	35.00	.75	75.00
	Class 4	100	.72	72.00	.60	60.00	.80	80.00
	Overhaul	180,000	.01¾	3,150.00	.01¼	2,250.00	.01	1,800.00
	Puddle	1,000	.40	400.00	.75	750.00	.75	750.00
	Total			45,772.00		42,745.00		42,332.00
3	Excavation:							
	Class 1	280,000	.13½	37,800.00	.12½	35,000.00	.11.99	33,572.00
	Class 2	27,000	.39	10,530.00	.50	13,500.00	.60	16,200.00
	Class 3	100	.35	35.00	.35	35.00	.70	70.00
	Class 4	38,000	.72	27,360.00	.70	26,600.00	.75	28,500.00
	Overhaul	180,000	.01¾	3,150.00	.01¼	2,250.00	.01	1,800.00
	Puddle	1,000	.40	400.00	.75	750.00	.75	750.00
	Total			79,275.00		78,135.00		80,892.00
4	Excavation:							
	Class 1	45,000	.14	6,300.00	.15	6,750.00	.11.99	5,395.50
	Class 2	79,000	.39	30,810.00	.50	39,500.00	.60	47,400.00
	Class 3	100	.35	35.00	.35	35.00	.75	75.00
	Class 4	100	.72	72.00	.60	60.00	.80	80.00
	Overhaul	120,000	.01¾	2,100.00	.01¼	1,500.00	.01	1,200.00
	Puddle	1,000	.40	400.00	.75	750.00	.75	750.00
	Total			39,717.00		48,595.00		54,900.50
5	Excavation:							
	Class 1	346,000	.14	48,440.00	.15	51,900.00	.18	62,280.00
	Class 2	26,000	.40	10,400.00	.50	13,000.00	.60	15,600.00
	Class 3	100	.35	35.00	.35	35.00	.75	75.00
	Class 4	100	.72	72.00	.60	60.00	.80	80.00
	Overhaul	670,000	.02	13,400.00	.01¼	8,375.00	.01½	10,050.00
	Puddle	10,000	.43	4,300.00	.75	7,500.00	.75	7,500.00
	Total			76,647.00		80,870.00		95,585.00

[a] No conditions.

[b] This bid is made on a basis only of each division as a whole.

Bids for first contract, Interstate canal, North Platte project—Continued.

Division.	Work.	Quantity in cubic yards.	Orman & Crook. Pueblo, Colo., ten $2,000 cash checks.		Griffith & McDermott, 1011 Merchant's Loan & Trust Building, Chicago, Ill., one $20,000 check.		Robinson & Maney. 1609 Chemical Building, St. Louis, Mo., one $9,000 certified check, one $1,000 cash check, five $2,000 cash checks.	
			Unit price.	Amount.	Unit price.	Amount.	Unit pri.e.	Amount.
6	Excavation:							
	Class 1	300,000	$0.12	$36,000.00	\$0.11$\frac{7}{10}$	$35,100.00	$0.10.99	$32,970.00
	Class 2	100	.46	40.00	.50	50.00	.60	60.00
	Class 3	100	.35	35.00	.35	35.00	.75	75.00
	Class 4	100	.72	72.00	.60	60.00	.80	80.00
	Overhaul	140,000	.01¾	2,450.00	.01¼	1,750.00	.01	1,400.00
	Puddle	1,000	.40	400.00	.75	750.00	.75	750.00
	Total			38,997.00		37,745.00		35,335.00
7	Excavation:							
	Class 1	300,000	.12	36,000.00	.11.7	35,100.00	.10.99	32,970.00
	Class 2	100	.40	40.00	.50	50.00	.60	60.00
	Class 3	100	.35	35.00	.35	35.00	.75	75.00
	Class 4	100	.72	72.00	.60	60.00	.80	80.00
	Overhaul	120,000	.01¾	2,100.00	.01¼	1,500.00	.01	1,200.00
	Puddle	1,000	.40	400.00	.75	750.00	.75	750.00
	Total			38,647.00		37,495.00		35,135.00
8	Excavation:							
	Class 1	295,000	.12½	36,875.00	.13	38,850.00	.11.99	35,370.50
	Class 2	100	.40	40.00	.50	50.00	.60	60.00
	Class 3	100	.35	35.00	.35	35.00	.75	75.00
	Class 4	100	.72	72.00	.60	60.00	.80	80.00
	Overhaul	140,000	.01¾	2,450.00	.01¼	1,750.00	.01	1,400.00
	Puddle	1,000	.40	400.00	.75	750.00	.75	750.00
	Total			39,872.00		40,995.00		37,735.50
9	Excavation:							
	Class 1	282,000	.12½	35,250.00	.11.7	32,994.00	.10.99	30,991.80
	Class 2	100	.40	40.00	.50	50.00	.60	60.00
	Class 3	100	.35	35.00	.35	35.00	.75	75.00
	Class 4	100	.72	72.00	.60	60.00	.80	80.00
	Overhaul	131,000	.01¾	2,292.50	.01¼	1,637.50	.01	1,310.00
	Puddle	1,000	.40	400.00	.75	750.00	.75	750.00
	Total			38,089.50		35,526.50		33,266.80
10	Excavation:							
	Class 1	250,000	.12½	31,250.00	.11.7	29,250.00	.10.99	27.475.00
	Class 2	100	.40	40.00	.50	50.00	.60	60.00
	Class 3	100	.35	35.00	.35	35.00	.75	75.00
	Class 4	100	.72	72.00	.60	60.00	.80	80.00
	Overhaul	126,000	.01¾	2,205.00	.01¼	1,575.00	.01	1,260.00
	Puddle	1,000	.40	400.00	.75	750.00	.75	750.00
	Total			34,002.00		31,720.00		29,700.00

Bids for first contract, Interstate canal, North Platte project—Continued.

Division.	Work.	Quantity in cubic yards.	James O. Connor, Morgantown, Ind., four $2,000 certified checks.[a]		Deadwood Construction Co., Deadwood, S. Dak., two $2,000 certified checks.[b]		Kilpatrick Bros. & Collins Contracting Co., Beatrice, Nebr., one $2,000 certified check.[c]	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
1	Excavation:							
	Class 1	260,000					$0.13¾	$35,750.00
	Class 2	10,000					.37	3,700.00
	Class 3	100					.47	47.00
	Class 4	1,500					.67	1,005.00
	Overhaul	140,000					.01¼	1,750.00
	Puddle	1,000					.57	570.00
	Total							42,822.00
2	Excavation:							
	Class 1	330,000					.13¾	45,375.00
	Class 2	100					.37	37.00
	Class 3	100					.47	47.00
	Class 4	100					.67	67.00
	Overhaul	180,000					.01¼	2,250.00
	Puddle	1,000					.57	570.00
	Total							48,346.00
3	Excavation:							
	Class 1	280,000			$0.14½	$40,600.00	.13¾	38,500.00
	Class 2	27,000			.29	7,830.00	.37	9,990.00
	Class 3	100			.35	35.00	.47	47.00
	Class 4	38,000			.82	31,160.00	.67	25,460.00
	Overhaul	180,000			.02	3,600.00	.01¼	2,250.00
	Puddle	1,000			.50	500.00	.57	570.00
	Total					83,725.00		76,817.00
4	Excavation:							
	Class 1	45,000			.15	6,750.00	.13¾	6,187.50
	Class 2	79,000			.29	22,910.00	.37	29,230.00
	Class 3	100			.35	35.00	.47	47.00
	Class 4	100			1.00	100.00	.67	67.00
	Overhaul	120,000			.02	2,400.00	.01¼	1,500.00
	Puddle	1,000			.50	500.00	.57	570.00
	Total					32,695.00		37,601.50
5	Excavation:							
	Class 1	346,000					.13¾	47,575.00
	Class 2	26,000					.37	9,620.00
	Class 3	100					.47	47.00
	Class 4	100					.67	67.00
	Overhaul	670,000					.01¼	8,375.00
	Puddle	10,000					.57	5,700.00
	Total							71,384.00

[a] My bid in divisions Nos. 7, 8, 9, and 10 is submitted under paragraph 1 of circular.

[b] This bid is for all of this division or none.

[c] This proposal is made with the understanding that if award is made thereon contract shall cover all work in division 1 to 10, both inclusive, on which prices are named herein.

Bids for first contract, Interstate canal, North Platte project—Continued.

Division.	Work.	Quantity in cubic yards.	James O. Connor, Morgantown, Ind., four $2,000 certified checks.		Deadwood Construction Co., Deadwood, S. Dak., two $2,000 certified checks.		Kilpatrick Bros. & Collins Contracting Co., Beatrice, Nebr., one $20,000 certified check.	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
6	Excavation:							
	Class 1	300,000					$0.13¾	$41,250.00
	Class 2	100					.37	37.00
	Class 3	100					.47	47.00
	Class 4	100					.67	67.00
	Overhaul	140,000					.01¼	1,750.00
	Puddle	1,000					.57	570.00
	Total							43,721.00
7	Excavation:							
	Class 1	300,000	$0.12	$36,000.00			.13¾	41,250.00
	Class 2	100	.35	35.00			.37	37.00
	Class 3	100	.45	45.00			.47	47.00
	Class 4	100	.80	80.00			.67	67.00
	Overhaul	120,000	.01	1,200.00			.01¼	1,500.00
	Puddle	1,000	.60	600.00			.57	570.00
	Total			37,960.00				43,471.00
8	Excavation:							
	Class 1	295,000	.12	35,400.00			.13¾	40,562.50
	Class 2	100	.35	35.00			.37	37.00
	Class 3	100	.45	45.00			.47	47.00
	Class 4	100	.80	80.00			.67	67.00
	Overhaul	140,000	.01	1,400.00			.01¼	1,750.00
	Puddle	1,000	.60	600.00			.57	570.00
	Total			37,560.00				43,033.50
9	Excavation:							
	Class 1	282,000	.11.7	32,994.00			.13¾	38,775.00
	Class 2	100	.35	35.00			.37	37.00
	Class 3	100	.45	45.00			.47	47.00
	Class 4	100	.80	80.00			.67	67.00
	Overhaul	131,000	.01	1,310.00			.01¼	1,637.50
	Puddle	1,000	.60	600.00			.57	570.00
	Total			35,064.00				41,133.50
10	Excavation:							
	Class 1	250,000	.11.7	29,250.00			.13¾	34,375.00
	Class 2	100	.35	35.00			.37	37.00
	Class 3	100	.45	45.00			.47	47.00
	Class 4	100	.80	80.00			.67	67.00
	Overhaul	126,000	.01	1,260.00			.01¼	1,575.00
	Puddle	1,000	.60	600.00			.57	570.00
	Total			31,270.00				36,671.00

Bids for first contract, Interstate canal, North Platte project—Continued.

Division.	Work.	Quantity in cubic yards.	The Burke Construction Co., St. Louis, Mo., ten $2,000 certified checks.[a]		The Burke Construction Co., St. Louis, Mo.[b]		D. J. Burke, Guernsey, Wyo. five $2,000 cash checks, one $10,000 cash check.[c]	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
1	Excavation:							
	Class 1	260,000	$0.15.4	$40,040.00	$0.15	$39,000.00	$0.22	$57,200.00
	Class 2	10,000	.42	4,200.00	.41	4,100.00	.70	7,000.00
	Class 3	100	.53	53.00	.55	55.00	.38	38.00
	Class 4	1,500	.85	1,275.00	1.00	1,500.00	.85	1,375.00
	Overhaul	140,000	.01½	2,100.00	.01½	2,100.00	.01½	2,100.00
	Puddle	1,000	.45	450.00	.50	500.00	.35	350.00
	Total	....	....	48,118.00	....	47,255.00	....	67,968.00
2	Excavation:							
	Class 1	330,000	.15.4	50,820.00	.15	49,500.00	.14½	47,850.00
	Class 2	100	.42	42.00	.41	41.00	.65	65.00
	Class 3	100	.53	53.00	.55	55.00	.35	35.00
	Class 4	100	.85	85.00	1.00	100.00	.85	85.00
	Overhaul	180,000	.01½	2,700.00	.01½	2,700.00	.01½	2,700.00
	Puddle	1,000	.45	450.00	.50	500.00	.40	400.00
	Total	....	....	54,150.00	....	52,896.00	....	51,136.00
3	Excavation:							
	Class 1	280,000	.15.4	43,120.00	.14.5	40,600.00	.15	42,000.00
	Class 2	27,000	.42	11,340.00	.39	10,530.00	.75	20,250.00
	Class 3	100	.53	53.00	.55	55.00	.35	35.00
	Class 4	38,000	.85	32,300.00	.85	32,300.00	.88	33,440.00
	Overhaul	180,000	.01½	2,700.00	.01½	2,700.00	.01½	2,700.00
	Puddle	1,000	.45	450.00	.50	500.00	.50	500.00
	Total	....	....	89,963.00	....	86,685.00	....	98,925.00
4	Excavation:							
	Class 1	45,000	.15.4	6,930.00	.17.5	7,875.00	.20	9,000.00
	Class 2	79,000	.42	33,180.00	.43	33,970.00	.75	59,250.00
	Class 3	100	.53	53.00	.55	55.00	.35	35.00
	Class 4	100	.85	85.00	1.00	100.00	.85	85.00
	Overhaul	120,000	.01½	1,800.00	.01½	1,800.00	.02	2,400.00
	Puddle	1,000	.45	450.00	.50	500.00	.55	550.00
	Total	....	....	42,498.00	....	44,300.00	....	71,320.00
5	Excavation:							
	Class 1	346,000	.15.4	53,284.00	.21	72,660.00	.18.5	64,010.00
	Class 2	26,000	.42	10,920.00	.45	11,700.00	.75	19,500.00
	Class 3	100	.53	53.00	.55	55.00	.35	35.00
	Class 4	100	.85	85.00	1.00	100.00	.85	85.00
	Overhaul	670,000	.01½	10,050.00	.01½	10,050.00	.02	13,400.00
	Puddle	10,000	.45	4,500.00	.40	4,000.00	.65	6,500.00
	Total	....	....	78,892.00	....	98,565.00	....	103,530.00

[a] Proposal for contract awarded as a whole.
[b] Proposal if awarded by division.
[c] On my bid I wish to bid on each division as a total.

Bids for first contract, Interstate canal, North Platte project—Continued.

Division.	Work.	Quantity in cubic yards.	The Burke Construction Co., St. Louis, Mo., ten $2,000 certified checks.		The Burke Construction Co., St. Louis, Mo.		D. J. Burke, Guernsey, Wyo. five $2,000 cash checks, one $10,000 cash check.	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
6	Excavation:							
	Class 1	300,000	$0.15.4	$46,200.00	$0.14	$42,000.00	$0.14½	$43,500.00
	Class 2	100	.42	42.00	.45	45.00	.75	75.00
	Class 3	100	.53	53.00	.55	55.00	.35	35.00
	Class 4	100	.85	85.00	1.00	100.00	.80	80.00
	Overhaul	140,000	.01½	2,100.00	.01½	2,100.00	.01½	2,100.00
	Puddle	1,000	.45	450.00	.50	500.00	.75	750.00
	Total			48,930.00		44,800.00		46,540.00
7	Excavation:							
	Class 1	300,000	.15.4	46,200.00	.14.5	43,500.00	.14½	43,500.00
	Class 2	100	.42	42.00	.45	45.00	.75	75.00
	Class 3	100	.53	53.00	.55	55.00	.35	35.00
	Class 4	100	.85	85.00	1.00	100.00	.80	80.00
	Overhaul	120,000	.01½	1,800.00	.01½	1,800.00	.01½	1,800.00
	Puddle	1,000	.45	450.00	.50	500.00	1.00	1,000.00
	Total			48,630.00		46,000.00		46,490.00
8	Excavation:							
	Class 1	295,000	.15.4	45,430.00	.19.5	57,525.00	.16	47,200.00
	Class 2	100	.42	42.00	.45	45.00	.65	65.00
	Class 3	100	.53	53.00	.55	55.00	.35	75.00
	Class 4	100	.85	85.00	1.00	100.00	.85	85.00
	Overhaul	140,000	.01½	2,100.00	.01½	2,100.00	.01½	2,100.00
	Puddle	1,000	.45	450.00	.50	500.00	1.25	1,750.00
	Total			48,160.00		60,325.00		50,775.00
9	Excavation:							
	Class 1	282,000	.15.4	43,428.00	.14	39,480.00	.14½	40,890.00
	Class 2	100	.42	42.00	.45	45.00	.75	75.00
	Class 3	100	.53	53.00	.55	55.00	.35	35.00
	Class 4	100	.85	85.00	1.00	100.00	.80	80.00
	Overhaul	131,000	.01½	1,965.00	.01½	1,965.00	.02	2,620.00
	Puddle	1,000	.45	450.00	.40	400.00	1.25	1,250.00
	Total			46,023.00		42,095.00		44,950.00
10	Excavation:							
	Class 1	250,000	.15.4	38,500.00	.14	35,000.00	.15	37,500.00
	Class 2	100	.42	42.00	.45	45.00	.75	75.00
	Class 3	100	.53	53.00	.55	55.00	.38	38.00
	Class 4	100	.85	85.00	1.00	100.00	1.00	100.00
	Overhaul	126,000	.01½	1,890.00	.01½	1,890.00	.01¾	2,205.00
	Puddle	1,000	.45	450.00	.40	400.00	1.50	1,500.00
	Total			41,020.00		37,490.00		41,418.00

Bids for first contract, Interstate canal, North Platte project—Continued.

Division.	Work.	Quantity in cubic yards.	W. C. Bradbury, 55-56 Railroad Building, Denver, Colo., ten $2,000 certified checks.[a]		Keltie Contracting Co., Joliet, Ill., one $12,000 certified check.[b]		Wood, Bancroft & Doty, David City, Nebr., four $2,000 certified checks.[c]	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
1	Excavation:							
	Class 1	260,000	$0.15½	$40,300.00				
	Class 2	10,000	.58	5,800.00				
	Class 3	100	.58	58.00				
	Class 4	1,500	.90	1,350.00				
	Overhaul	140,000	.01¾	2,450.00				
	Puddle	1,000	.30	300.00				
	Total			50,258.00				
2	Excavation:							
	Class 1	330,000	.15½	51,150.00				
	Class 2	100	.58	58.00				
	Class 3	100	.58	58.00				
	Class 4	100	.90	90.00				
	Overhaul	180,000	.01¾	3,150.00				
	Puddle	1,000	.30	300.00				
	Total			54,806.00				
3	Excavation:							
	Class 1	280,000	.15½	43,400.00				
	Class 2	27,000	.58	15,660.00				
	Class 3	100	.58	58.00				
	Class 4	38,000	.90	34,200.00				
	Overhaul	180,000	.01¾	3,150.00				
	Puddle	1,000	.30	300.00				
	Total			96,768.00				
4	Excavation:							
	Class 1	45,000	.15½	6,975.00				
	Class 2	79,000	.58	45,820.00				
	Class 3	100	.58	58.00				
	Class 4	100	.90	90.00				
	Overhaul	120,000	.01¾	2,100.00				
	Puddle	1,000	.30	300.00				
	Total			55,343.00				
5	Excavation:							
	Class 1	346,000	.15½	53,630.00	$0.15	$51,900.00		
	Class 2	26,000	.58	15,080.00	.50	13,000.00		
	Class 3	100	.58	58.00	.75	75.00		
	Class 4	100	.90	90.00	5.00	500.00		
	Overhaul	670,000	.01¾	11,725.00	.01	6,700.00		
	Puddle	10,000	.30	3,000.00	2.50	25,000.00		
	Total			83,583.00		97,175.00		

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[a] Six per cent discount from above prices if awarded entire work.
[b] On each division "This bid for all or none."
[c] This bid is for whole of this division, as per first condition in circular letter.

Bids for first contract, Interstate canal, North Platte project—Continued.

Division.	Work.	Quantity in cubic yards.	W. C. Bradbury, 55-56 Railroad Building, Denver, Colo., ten $2,000 certified checks.		Keltie Contracting Co., Joliet, Ill., one $12,000 certified check.		Wood, Bancroft & Doty, David City, Nebr., four $2,000 certified checks.	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
6	Excavation:							
	Class 1..........	300,000	$0.15½	$46,500.00	$0.16	$48,000.00	....	....
	Class 2..........	100	.58	58.00	.50	50.00	....	....
	Class 3..........	100	.58	58.00	.75	75.00	....	....
	Class 4..........	100	.90	90.00	.90	90.00	....	....
	Overhaul...........	140,000	.01¾	2,450.00	.01	1,400.00	....	....
	Puddle.............	1,000	.30	300.00	2.50	2,500.00	....	....
	Total.........	....	....	49,456.00	....	52,115.00	....	....
7	Excavation:							
	Class 1..........	300,000	.15½	46,500.00	.16	48,000.00	$0.12½	$37,500.00
	Class 2..........	100	.58	58.00	.50	50.00	.20	20.00
	Class 3..........	100	.58	58.00	.75	75.00	.30	30.00
	Class 4..........	100	.90	90.00	.90	90.00	.60	60.00
	Overhaul...........	120,000	.01¾	2,100.00	.01	1,200.00	.01½	1,800.00
	Puddle.............	1,000	.30	300.00	2.50	2,500.00	.50	500.00
	Total.........	....	....	49,106.00	....	51,915.00	....	39,910.00
8	Excavation:							
	Class 1..........	295,000	.15½	45,725.00	.16	47,200.00	.12½	36,875.00
	Class 2..........	100	.58	58.00	.50	50.00	.20	20.00
	Class 3..........	100	.58	58.00	.75	75.00	.30	30.00
	Class 4..........	100	.90	90.00	.90	90.00	.60	60.00
	Overhaul...........	140,000	.01¾	2,450.00	.01	1,400.00	.01½	2,100.00
	Puddle.............	1,000	.30	300.00	2.50	2,500.00	.50	500.00
	Total.........	....	....	48,681.00	....	51,315.00	....	39,585.00
9	Excavation:							
	Class 1..........	282,000	.15½	43,710.00	.16	45,120.00	.12	33,840.00
	Class 2..........	100	.58	58.00	.50	50.00	.20	20.00
	Class 3..........	100	.58	58.00	.75	75.00	.30	30.00
	Class 4..........	100	.90	90.00	.90	90.00	.60	60.00
	Overhaul...........	131,000	.01¾	2,292.50	.01	1,310.00	.01½	1,965.00
	Puddle.............	1,000	.30	300.00	2.50	2,500.00	.50	500.00
	Total.........	....	....	46,508.50	....	49,145.00	....	36,415.00
10	Excavation:							
	Class 1..........	250,000	.15½	38,750.00	.16	40,000.00	.12	30,000.00
	Class 2..........	100	.58	58.00	.50	50.00	.20	20.00
	Class 3..........	100	.58	58.00	.75	75.00	.30	30.00
	Class 4..........	100	.90	90.00	.90	90.00	.60	60.00
	Overhaul...........	126,000	.01¾	2,205.00	.01	1,260.00	.01½	1,890.00
	Puddle.............	1,000	.30	300.00	2.50	2,500.00	.50	500.00
	Total.........	....	....	41,461.00	....	43,975.00	....	32,500.00

Bids for first contract, Interstate canal, North Platte project—Continued.

Division.	Work.	Quantity in cubic yards.	The Denver and Pueblo Construction Co., Denver, Colo., three $2,000 certified checks.[a]		Streeter & Lusk Co., Denver, Colo., five $2,000 cash checks.[b]		R. P. Scott, Bridgeport, Nebr., one $2,000 certified check.[c]		Monarch & Porter, Des Moines, Iowa, one $2,000 certified check.[d]	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
3	Excavation:									
	Class 1....	280,000	....	....	$0.15	$42,000.00	....	....	$0.12	$33,600.00
	Class 2....	27,000	....	....	.40	10,800.00	....	....	.35	9,450.00
	Class 3....	100	....	....	.90	90.00	....	....	.50	50.00
	Class 4....	38,000	....	....	.90	34,200.00	....	....	.90	34,200.00
	Overhaul.....	180,000	....	....	.01¼	2,250.00	....	....	.01	1,800.00
	Puddle.......	1,000	....	....	1.00	1,000.00	....	....	.50	500.00
	Total...	....	....	....	....	90,340.00	....	....	....	79,600.00
5	Excavation:									
	Class 1....	346,000	....	....	.17	58,820.00	....	....	....	....
	Class 2....	26,000	....	....	.40	10,400.00	....	....	....	....
	Class 3....	100	....	....	1.00	100.00	....	....	....	....
	Class 4....	100	....	....	1.00	100.00	....	....	....	....
	Overhaul.....	670,000	....	....	.01¼	8,375.00	....	....	....	....
	Puddle.......	10,000	....	....	1.00	10,000.00	....	....	....	....
	Total...	....	....	....	....	87,795.00	....	....	....	....
6	Excavation:									
	Class 1....	300,000	....	....	.14½	43,500.00	....	....	....	....
	Class 2....	100	....	....	1.00	100.00	....	....	....	....
	Class 3....	100	....	....	1.00	100.00	....	....	....	....
	Class 4....	100	....	....	1.00	100.00	....	....	....	....
	Overhaul.....	140,000	....	....	.01¼	1,750.00	....	....	....	....
	Puddle.......	1,000	....	....	1.00	1,000.00	....	....	....	....
	Total...	....	....	....	....	46,550.00	....	....	....	....
7	Excavation:									
	Class 1....	300,000	$0.12½	$37,500.00	.14½	43,500.00	....	....	....	....
	Class 2....	100	.50	50.00	1.00	100.00	....	....	....	....
	Class 3....	100	.70	70.00	1.00	100.00	....	....	....	....
	Class 4....	100	.90	90.00	1.00	100.00	....	....	....	....
	Overhaul.....	120,000	.01	1,200.00	.01¼	1,500.00	....	....	....	....
	Puddle.......	1,000	.05	50.00	1.00	1,000.00	....	....	....	....
	Total...	....	....	38,960.00	....	46,300.00	....	....	....	....

[a] No conditions.
[b] In our bid we wish to bid for each division in total.
[c] I desire to bid on the divisions as a whole.
[d] The above prices for the divisions as a whole.

Bids for first contract, Interstate canal, North Platte project—Continued.

Division.	Work.	Quantity in cubic yards.	The Denver and Pueblo Construction Co., Denver, Colo., three $2,000 certified checks.		Streeter & Lusk Co., Denver, Colo., five $2,000 cash checks.		R. P. Scott Bridgeport, Nebr., one $2,000 certified check.		Monarch & Porter, Des Moines, Iowa, one $2,000 certified check.	
			Unit price	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
8	Excavation:									
	Class 1....	295,000	....	....	$0.15	$44,250.00	....	....	....	....
	Class 2....	100	....	....	1.00	100.00	....	....	....	....
	Class 3....	100	....	....	1.00	100.00	....	....	....	....
	Class 4....	100	....	....	1.00	100.00	....	....	....	....
	Overhaul.....	140,000	....	....	.01¼	1,750.00	....	....	....	....
	Puddle.......	1,000	....	....	1.00	1,000.00	....	....	....	....
	Total...	....	....	....	....	47,300.00	....	....	....	....
9	Excavation:									
	Class 1....	282,000	$0.12¾	$35,955.00	....	....	....	....	....	....
	Class 2....	100	.30	30.00	....	....	....	....	....	....
	Class 3....	100	.50	50.00	....	....	....	....	....	....
	Class 4....	100	.85	85.00	....	....	....	....	....	....
	Overhaul.....	131,000	.01	1,310.00	....	....	....	....	....	....
	Puddle.......	1,000	.03	30.00	....	....	....	....	....	....
	Total...	....	....	37,460.00	....	....	....	....	....	....
10	Excavation:									
	Class 1....	250,000	.12¾	31,875.00	....	....	$0.14½	$36,250.00	....	....
	Class 2....	100	.60	60.00	....	....	.30	30.00	....	....
	Class 3....	100	.74	74.00	....	....	.42	42.00	....	....
	Class 4....	100	1.00	100.00	....	....	.76	76.00	....	....
	Overhaul.....	126,000	.01$\frac{2}{10}$	1,512.00	....	....	.01$\frac{4}{10}$	1,764.00	....	....
	Puddle.......	1,000	.05	50.00	....	....	.22	220.00	....	....
	Total...	....	....	33,671.00	....	....	....	38,382.00	....	....

Bids for structures for Interstate canal, North Platte project, Nebraska.

SCHEDULE NO. 1.

Work or material.	Quantity.	W. O. Morrison, Denver, Colo.		Guy F. Atkinson, Colorado Springs, Colo.		Robinson & Maney, St. Louis, Mo.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Concrete:							
Class 1	570 cubic yards	$5.30	$3,021.00	$7.00	$3,990.00	$11.00	$6,270.00
Class 2	430 cubic yards	10.80	4,644.00	10.00	4,300.00	15.00	6,450.00
Class 1, in floor and side walls of flood-water intake.	1,800 cubic yards	5.10	9,180.00	6.00	10,800.00	11.00	19,800.00
Steel for reinforcing.	28,000 pounds	.0275	770.00	.05	1,400.00	.0475	1,330.00
L beams	90,000 pounds	.0375	3,375.00	.05	4,500.00	.045	4,050.00
Clinton wire fabric.	600 pounds	.099	59.40	.10	60.00	.06	36.00
Lattice girders	5,000 pounds	.058	290.00	.06	300.00	.05	250.00
Puddle	80 cubic yards	1.20	96.00	2.00	160.00	1.50	120.00
Grouted paving	40 cubic yards	5.50	220.00	4.00	160.00	5.00	200.00
Riprap or dry rock paving.	200 cubic yards	4.30	860.00	4.00	800.00	4.00	800.00
Screened gravel for bowlders.	100 cubic yards	1.30	130.00	2.00	200.00	3.00	300.00
Excavation:							
Class 1	8,000 cubic yards	.38	3,040.00	.40	3,200.00	.50	4,000.00
Class 4	400 cubic yards	3.00	1,200.00	4.00	1,600.00	2.00	800.00
Common lumber.	5,000 feet B. M.	34.00	170.00	50.00	250.00	45.00	225.00
Overhaul equivalent to.	1,000 cubic yards, hauled 100 feet.	.015	15.00	.015	15.00	.015	15.00
Total			27,070.40		31,735.00		44,646.00

Bids for structures for Interstate canal, North Platte project, Nebraska—Continued.

SCHEDULE NO. 2.

Work or material.	Quantity.	W. O. Morrison, Denver, Colo.		Lyn S. Atkinson, Colorado Springs, Colo.		Robinson & Maney, St. Louis, Mo.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Concrete:							
Class 1	4,200 cubic yards	$6.60	$27,720.00	$8.00	$33,600.00	$11.00	$46,200.00
Class 2	2,700 cubic yards	10.90	29,430.00	11.60	31,320.00	15.00	40,500.00
Steel for reinforcing.	285,000 pounds	.0327	9,319.50	.04	11,400.00	.0475	13,573.50
Kahn bars for reinforcing.	120,000 pounds	.0468	5,616.00	.045	5,400.00	.04	4,800.00
Lattice girders	27,000 pounds	.055	1,485.00	.06	1,620.00	.05	1,350.00
Clinton fabric or equivalent.	15,000 pounds	.099	1,485.00	.10	1,500.00	.06	900.00
Grouted paving	200 cubic yards	5.25	1,050.00	5.00	1,000.00	5.00	1,000.00
Riprap or dry rock paving.	do	4.30	860.00	4.00	800.00	4.00	800.00
Gravel-bowlder backing for concrete lining.	900 cubic yards	2.30	2,070.00	2.00	1,800.00	5.00	4,500.00
Screened gravel and bowlders.	3,000 cubic yards	2.20	6,600.00	2.50	7,500.00	4.00	12,000.00
Puddle	1,500 cubic yards	1.25	1,875.00	1.50	2,250.00	1.50	2,250.00
Excavation:							
Class 1	15,000 cubic yards.	.36	5,400.00	.60	9,000.00	..30	4,500.00
Class 2	100 cubic yards	.72	72.00	1.25	125.00	2.00	200.00
Class 3	do	1.25	125.00	4.00	400.00	2.00	200.00
Class 4	do	4.00	400.00	2.00	200.00	2.50	250.00
Common lumber.	5,000 feet B. M	36.00	180.00	40.00	200.00	45.00	225.00
Overhaul equivalent to.	1,000 cubic yards hauled 100 feet.	.015	15.00	.015	15.00	.015	15.00
Highway bridges	8 66-foot spans	1,018.00	8,144.00	1,150.00	9,200.00	1,250.00	10,000.00
Do	2 60-foot spans	980.00	1,960.00	1,050.00	2,100.00	1,200.00	2,400.00
Total			103,806.50		119,430.00		145,627.50

Bids for second contract for main canal, Interstate canal, North Platte project, Nebraska.

DIVISION NO. 1.

Kind of work.	Quantity in cubic yards.	Deadwood Construction Co., Deadwood, S. Dak.		James O'Connor, Mitchell, Nebr.		The Burke Construction Co., St. Louis, Mo.		Robinson & Maney, St. Louis, Mo.		Kilpatrick Bros. & Collins, Beatrice, Nebr.		W. F. Callahan & Son, Omaha, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:													
Class 1	370,000	$0.1398	$51,726.00					$0.15	$55,500.00	$0.195	$72,150.00		
Class 2	1 000	.55	550.00					.60	600.00	.64	640.00		
Class 3	100	.45	45.00					.65	65.00	1.00	100.00		
Class 4	100	.50	50.00					.75	75.00	1.50	150.00		
Overhaul	60,000	.015	900.00					.015	900.00	.015	900.00		
Total			53,271.00						57,140.00		73,940.00		

DIVISION NO. 2.

Kind of work.	Quantity in cubic yards.	Deadwood Construction Co., Deadwood, S. Dak.		James O'Connor, Mitchell, Nebr.		The Burke Construction Co., St. Louis, Mo.		Robinson & Maney, St. Louis, Mo.		Kilpatrick Bros. & Collins, Beatrice, Nebr.		W. F. Callahan & Son, Omaha, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:													
Class 1	400,000	$0.13	$52,000.00					$0.15	$60,000.00	$0.185	$74,000.00		
Class 2	1,000	.50	500.00					.60	600.00	.64	640.00		
Class 3	100	.45	45.00					.65	65.00	1.00	100.00		
Class 4	100	.50	50.00					.75	75.00	1.50	150.00		
Overhaul	120,000	.015	1,800.00					.015	1,800.00	.015	1,800.00		
Total			54,395.00						62,540.00		76,690.00		

DIVISION NO. 3.

Kind of work.	Quantity in cubic yards.	Deadwood Construction Co., Deadwood, S. Dak.		James O'Connor, Mitchell, Nebr.		The Burke Construction Co., St. Louis, Mo.		Robinson & Maney, St. Louis, Mo.		Kilpatrick Bros. & Collins, Beatrice, Nebr.		W. F. Callahan & Son, Omaha, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:													
Class 1	380,000	$0.145	$55,100.00					$0.15	$57,000.00	$0.18	$68,400.00		
Class 2	24,000	.55	13,200.00					.60	14,400.00	.64	15,360.00		
Class 3	100	.45	45.00					.65	65.00	1.00	100.00		
Class 4	100	.50	50.00					.75	75.00	1.50	150.00		

Overhaul	80,000	.015	1,200.00	....	....	....	....	.015	1,200.00	.015	1,200.00	....	....
Total	....	....	69,595.00	....	....	....	....	....	72,740.00	....	85,210.00	....	....

DIVISION NO. 4.

Excavation:													
Class 1	330,000	$0.13	$42,900.00	....	....	....	....	$0.15	$49,500.00	$0.1825	$60,225.00	....	....
Class 2	1,000	.55	550.00	....	....	....	....	.60	600.00	.64	640.00	....	....
Class 3	100	.45	45.00	....	....	....	....	.65	65.00	1.00	100.00	....	....
Class 4	100	.50	50.00	....	....	....	....	.75	75.00	1.50	150.00	....	....
Overhaul	140,000	.015	2,100.00	....	....	....	....	.015	2,100.00	.015	2,100.00	....	....
Total	....	....	45,645.00	....	....	....	....	....	52,340.00	....	63,215.00	....	....

DIVISION NO. 5.

Excavation:													
Class 1	300,000	$0.13	$39,000.00	$0.138	$41,400.00	$0.15	$45,000.00	$0.15	$45,000.00	$0.185	$55,500.00	....	....
Class 2	1,000	.55	550.00	.50	500.00	.45	450.00	.60	600.00	.64	640.00	....	....
Class 3	100	.45	45.00	.50	50.00	.55	55.00	.65	65.00	1.00	100.00	....	....
Class 4	100	.50	50.00	.90	90.00	.85	85.00	.75	75.00	1.50	150.00	....	....
Overhaul	160,000	.015	2,400.00	.015	2,400.00	.015	2,400.00	.015	2,400.00	.015	2,400.00	....	....
Total	....	....	42,045.00	....	44,440.00	....	47,990.00	....	48,140.00	....	58,790.00	....	....

DIVISION NO. 6.

Excavation:													
Class 1	340,000	$0.15	$51,000.00	$0.138	$46,920.00	$0.15	$51,000.00	$0.15	$51,000.00	$0.19	$64,600.00	....	....
Class 2	60,000	.55	33,000.00	.48	28,800.00	.45	27,000.00	.60	36,000.00	.64	38,400.00	....	....
Class 3	100	.45	45.00	.50	50.00	.55	55.00	.65	65.00	1.00	100.00	....	....
Class 4	100	1.00	100.00	.90	90.00	.85	85.00	.75	75.00	1.50	150.00	....	....
Overhaul	100,000	.015	1,500.00	.015	1,500.00	.015	1,500.00	.015	1,500.00	.015	1,500.00	....	....
Total	....	....	85,645.00	....	77,360.00	....	79,640.00	....	88,640.00	....	104,750.00	....	....

Bids for second contract for main canal, Interstate canal, North Platte project, Nebraska—Continued.

DIVISION NO. 7.

Kind of work.	Quantity in cubic yards.	Deadwood Construction Co., Deadwood, S. Dak.		James O'Connor, Mitchell, Nebr.		The Burke Construction Co., St. Louis, Mo.		Robinson & Maney, St. Louis, Mo.		Kilpatrick Bros. & Collins, Beatrice, Nebr.		W. F. Callahan & Son, Omaha, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:													
Class 1	380,000	$0.16	$60,800.00	....	....	$0.16	$60,800.00	$0.18	$68,400.00	$0.18	$68,400.00	$0.217	$82,460.00
Class 2	30,000	.60	18,000.00	....	....	.45	13,500.00	.60	18,000.00	.64	19,200.00	.50	15,000.00
Class 3	100	.45	45.00	....	....	.55	55.00	.65	65.00	1.00	100.00	.50	50.00
Class 4	100	1.00	100.00	....	....	.85	85.00	.75	75.00	1.50	150.00	.85	85.00
Overhaul	120,000	.015	1,800.00	....	....	.015	1,800.00	.015	1,800.00	.015	1,800.00	.015	1,800.00
Total	....	....	80,745.00	....	....	....	76,240.00	....	88,340.00	....	89,650.00	....	99,395.00

DIVISION NO. 8.

Kind of work.	Quantity in cubic yards.	Deadwood Construction Co., Deadwood, S. Dak.		James O'Connor, Mitchell, Nebr.		The Burke Construction Co., St. Louis, Mo.		Robinson & Maney, St. Louis, Mo.		Kilpatrick Bros. & Collins, Beatrice, Nebr.		W. F. Callahan & Son, Omaha, Nebr.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:													
Class 1	240,000	$0.135	$32,400.00	....	....	....	....	$0.15	$36,000.00	$0.1825	$43,800.00	$0.17	$40,800.00
Class 2	20,000	.55	11,000.00	....	....	....	....	.60	12,000.00	.64	12,800.00	.45	9,000.00
Class 3	100	.45	45.00	....	....	....	....	.65	65.00	1.00	100.00	.50	50.00
Class 4	100	.55	55.00	....	....	....	....	.75	75.00	1.50	150.00	.85	85.00
Overhaul	60,000	.015	900.00	....	....	....	....	.015	900.00	.015	900.00	.015	900.00
Total	....	....	44,400.00	....	....	....	....	....	49,040.00	....	57,750.00	....	50,835.00
Grand total	....	....	475,741.00	....	$121,800.00	....	$203,870.00	....	518,920.00	....	609,995.00	....	150,230.00

EXPENDITURES.

The expenditures on the North Platte project to September 30, 1905, were as follows:

Expenditures on North Platte project to September 30, 1905.

Pathfinder tunnel: Kilpatrick Bros. & Collins		$29,556.75
Interstate canal:		
Robinson & Maney	$3,720.45	
Deadwood Construction Co.	3,216.00	
Orman & Crook	9,174.10	
		16,110.55
Office buildings		4,000.00
Preliminary surveys		40,000.00
Location and testing		70,000.00
Design		5,000.00
Engineering and supervision		25,000.00
Administration		15,387.75
Total		205,055.05

SOUTH PLATTE UNDERFLOW INVESTIGATIONS.[a]

LOCATION.

Investigations were begun about the middle of July, 1905, in the South Platte Valley, extending from Sterling, Colo., to North Platte, Nebr., to determine the underflow and to ascertain whether it was practicable to make use of such underground waters for irrigation. Field work was completed September 22, 1905.

The South Platte Valley between the two points named varies in width from 2 to 8 miles. The river itself occupies a wide, sandy stretch ranging from 1,500 to 2,500 feet in width. It flows in this enormous bed in numerous interlocking small streams, from which it is difficult to select the principal channel. The bottom lands near the river are in many places low and swampy. These low bottoms differ greatly in width at different places, but even where they are widest they contain only a small area of land suitable for irrigation. Above these low bottom lands the valley slopes gently away from the channel, in some places in two or three distinct levels, in others with gradual slope without noticeable benches, to the base of the escarpment that borders the uplands on either side of the river. The uplands or table-lands in which the river is eroded stand at an elevation ranging from 150 to 200 feet above the level of the river and possess the well-known topography of the high plains of western Kansas and Nebraska.

Numerous irrigation canals have been taken out of Platte River at various points in Colorado and Nebraska. These canals carry water usually to the bottom lands only. At no place between Sterling and North Platte has it been possible to construct a canal to convey water to the uplands, for their elevation is too great to render such construction practicable. Where the irrigation systems have been properly constructed and maintained, the results obtained have been very satisfactory, except at the middle and the end of the irrigation season, when the farmers complain of shortage of water—a complaint frequently heard in irrigation districts. In order to augment the low-stage supply of water several reservoirs have been constructed in the Platte Valley in Colorado.

WATER-BEARING GRAVELS.

Inasmuch as irrigation must of necessity be confined to the bottom lands of the Platte Valley, it becomes especially important to know to what extent these lands can be irrigated by water drawn from the underflow of the river. This point was kept well in mind during the investigations.

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[a] From report by C. S. Slichter.

The gradient of the river channel along this portion of its course will average about 8 feet to the mile. The alluvial deposits consist of coarse sand mixed with gravels of various sizes, the largest about 1 inch in diameter. The larger pebbles are not deposited in separate streaks, but are scattered through and mixed with the coarse sand of the river deposits. In this respect the sands of South Platte River differ materially from the sands found in Arkansas River in western Kansas, where the larger pebbles are usually absent. The sands of the South Platte are free from deposits of quicksand and fine silt.

The presence of large pebbles in the sandy deposits of the South Platte Valley makes this material an excellent water-bearing gravel, very well adapted for the construction of wells of large capacity. By the use of proper strainers the smaller particles can be removed from the immediate neighborhood of the well, so that the water can be collected through the remaining coarser gravel. Material of this kind was found wherever sought for between Sterling, Colo., and North Platte, Nebr. It is believed that there is no considerable area in this part of the valley which is not underlain with gravel of this kind.

In order to determine the amount of water that can be obtained from such gravels by means of suitably constructed wells and pumping machinery it was planned to test the wells in the valley, but the number of pumping plants constructed was so small that it was not possible to get together a very large amount of data bearing upon this point. Such tests, however, as were possible indicate that wells of high capacity can be very economically constructed, and on this account no difficulty will be experienced in obtaining water in quantities suitable for irrigation.

SITUATION AT STERLING, COLO.

At Sterling, Colo., the valley of the South Platte is rather wide. A pumping plant constructed for irrigation is located on the Johnson ranch, on the east side of the river. The well used in connection with this pumping plant was a dug well which had been so poorly sheeted up that large quantities of sand entered the pump, so that the test was not satisfactory. It will be very easy, at small expense, so to modify the well as to keep the sand from the pump, when there will be no difficulty in procuring a large supply of water. The water-bearing gravels near Sterling extend to a depth of 40 to 80 feet below the surface of the ground, and there is abundant water for a large number of moderate-sized private pumping plants. It is believed that the ground water at this point may be best recovered by means of wells and pumping machinery, either owned by individual farmers or operated by electricity from a central plant. In this locality considerable interest is now taken in growing sugar beets. A large sugar factory has been built, from which it may be practicable to distribute power during the irrigation season to farmers in the neighborhood for the purpose of procuring water for irrigation. It is not advisable to put in pumping stations designed to take out a large amount of ground water, but would doubtless be more economical to restrict the amount of water taken at any one place to about 2,500 gallons a minute rather than to attempt to procure more than this. A large number of plants of moderate size will be much more economical and satisfactory in the long run than a smaller number of large plants.

UNDERFLOW INVESTIGATIONS AT OGALALLA, NEBR.

GENERAL CONDITIONS.

Reconnaissance work indicates that there is very little difference in the water-bearing gravels between Sterling, Colo., and Ogalalla, Nebr. The valley of the South Platte varies considerably in width, but the water-bearing material seems to be about the same. At Ogalalla the gravels vary in thickness from 25 to 65 feet. A series of test wells was sunk across the valley at this point and careful determinations were made both of the character of the water-bearing material and of the rate of movement of the underflow waters. The rate of movement of the ground water was determined by the electrical method described in Water-Supply and Irrigation Paper No. 110. The investigation showed that there is a true underflow of the river at this place. The ground waters move downstream with a velocity varying from 2.3 to 18 feet per twenty-four hours, the velocities of the ground water being about the same as on Arkansas River at the corresponding longitude in Kansas. The ground waters slope toward the river channel from both the north and the south side and contribute appreciably to the surface flow of the river.

QUANTITY OF THE UNDERFLOW.

The maximum amount of underflow water passing through the gravels in the valley of South Platte River at Ogalalla, Nebr., can be readily estimated. The cross section at this point is about the smallest that is found between North Platte, Nebr., and Sterling, Colo., but the slope of the water plane at this point is greater than the average slope in the valley. The total cross section of gravels capable of transmitting water is less than 330,000 square feet. The average velocity of the ground water in this material does not exceed 7 feet per twenty-four hours. The total amount of ground water passing between the river bluffs at Ogalalla therefore does not exceed 10 second-feet.

Although this amount of water is not large, yet it indicates that a considerable quantity of ground water can be safely removed from these underflow gravels. The water stored in the gravels can be drawn upon in large quantities, because the supply is renewed at frequent intervals by floods in the river and by rainfall upon adjacent lands. Any extended use of the ground water of the valley by means of pumps and wells would tend to lower the water plane, but this in turn would decrease materially the enormous amount of water that now goes to waste by evaporation from the sands and soils in the river valley and the adjacent bottom lands. The average amount of evaporation from these lands during July and August is undoubtedly as much as 12 inches per month.

UNDERFLOW CANAL AT OGALALLA.

One of the interesting developments in the South Platte Valley is an underflow ditch constructed in 1895 on the south side of the river near Ogalalla by A. Hollingsworth. This ditch, which is about 6,500 feet long, extends along the south bank of South Platte River on a grade less than that of the river bed, reaching a total depth, in its upper portion, of 5 feet below the bed of the river. The discharge from this ditch on August 5, 1905, was 3.78 second-feet. Later three weirs were placed at different points in the ditch and continuous records, made for a number of days, showed that the flow at midday was about 12 per cent less than the flow during the night.

The Hollingsworth underflow ditch is the only successful one of its kind on the western plains. The conditions at this point and the small size of the development are especially favorable to its success. The slope of South Platte River here is unusually great, amounting to about 1.6 feet in 1,000. The minimum slope of the underflow ditch is 0.7 feet in 1,000. The ditch cost about $8,000. It requires cleaning at frequent intervals, at least every two years, in order to remove vegetation and sand. The ditch is about as profitable as a pumping plant of the same cost and capacity in the same location, for the first cost and the cost of operation are not very different from the cost of constructing and operating a steam plant of the same size. In one respect a pumping plant would be much more satisfactory, for the ditch will become a total loss if an unusually heavy flood in the river should break over the banks and fill it or wash it out.

SOURCE OF THE UNDERFLOW.

The investigations show that the underflow waters of the South Platte are seepage waters that originate in rainfall on lands immediately adjacent to the valley on the north and south. Chemical analysis shows that the waters of the underflow are substantially identical with the well waters found on the uplands. Reports that the ground waters slope away from the river could not be verified, for levels run by the field party showed the slope in every instance to be toward the river.

An examination of the river made during the summer of 1905 left no doubt as to the source of the underflow. At this time the stream at Ogalalla was flowing in many small channels, a large number of which could be traced to their heads, where the seepage water formed their source. The behavior of the underflow ditch at Ogalalla also indicates the source of the supply. The south bank of this ditch—the one toward the valley lands and away from the river—was evidently supplying much more water to the ditch than the other side. If the ditch had not been in existence this water would have reached the river channel and formed one of the small streams, the aggregate of which constitutes the flow of the South Platte River during low stages of water. Near the channel of the underflow ditch the rate of movement in the direction of the river valley is very low, for the underflow waters at this place find relief in the artificial drainage furnished by the ditch and are not required to flow downstream through the gravels of the valley.

INVESTIGATIONS AT NORTH PLATTE.

Several miles of levels were run at this point to determine the slope of the water plane toward the bottom lands of the river, both north and south of the South Platte and North Platte rivers. The two rivers join a short distance below the city of North Platte. A series of levels were run at this place some years ago by W. W. Follett, to determine the position of the water plane. For lack of time a careful comparison of the former levels and those run during the current year has not been made, but the indications are that there has been no material change in the water plane during the fifteen years that have elapsed since the former levels were run.

SPRINGS AND ARTESIAN WATER AT BIRDWOOD CREEK.

Birdwood Creek, which enters the North Platte from the north about 15 miles west of North Platte, Nebr., is more than 20 miles long and receives from the west a branch about 15 miles long. Its drainage area lies almost entirely in the sand-hill district north of North Platte River. It is a perennial stream with a minimum low-stage flow of about 150 second-feet, and is fed for nearly its entire distance by small seeps along its banks and by numerous springs, some of which are of enormous size. Descriptions of these springs by residents of the valley indicated that the ground waters were under considerable artesian head, and this matter was therefore investigated. A small 2-inch test well was sunk to a depth of 40 feet and an artesian head of over 20 feet was developed, and the head increased as the well was sunk deeper. The water was unusually soft for western Nebraska and exceedingly good.

The waters of Birdwood Creek are taken out just above its mouth on the North Platte and diverted to a canal which is used to irrigate bottom lands along the river. The discovery of the artesian head of the water in Birdwood Creek will enable the low-stage flow of this stream and the supply of water for the existing irrigation canal, or a new one, to be greatly augmented. It will be an inexpensive matter to sink a number of 12-inch wells to the artesian water at suitable localities along the stream and to provide these wells with gates or valves which can be opened during the low stage of the stream.

CONCLUSIONS.

The reconnaissance in the valley of the South Platte indicates that there is an ample supply of ground water for irrigating lands in the bottoms along the valley. It is impracticable to divert any of the ground water from the valley of the South Platte and carry it to the uplands that border the valley, for the uplands here lie at too great an elevation above the bed of the river to permit the diversion to them of even the surface flow. A very considerable area of good bottom lands in the valley of the river proper are so situated as to be especially inviting for irrigation. The entire valley is traversed by the main line of an important railway system and would no doubt be capable of supporting a considerable population if engaged in intensive farming on small irrigated tracts. The gravels in the river valley are especially favorable for the construction of wells of large capacity, and pumping plants could probably be economically constructed and would prove profitable where the soil and markets are favorable. At places where the valley is wide, as at Sterling, Colo., and Big Springs, Nebr., it would seem practicable to construct a central power station and transmit power to numerous small pumping plants located on small holdings of irrigable land. It would seem practicable at Sterling to procure power from the large sugar factory which has been built at that place. At all points in the valley small pumping plants, owned by individual farmers, could be constructed for procuring a supply of water for irrigating high-grade crops. It is probable that it would not now pay to pump water to a greater height than 25 feet, including suction lift of the pump. In order to insure satisfactory results, great care must be exercised in constructing pumping plants for use in irrigation. It does not pay to purchase cheap pumps or poor machinery, for the running expense and wear and tear on such machinery soon make the total cost greater than that of a satisfactory and well-built plant.

The work done in this valley indicates that private capital can develop the water resources existing in the ground waters to the best advantage, and that there is no necessity here for large plants requiring large capital or Government aid. The situation seems to call for numerous small pumping plants rather than for a single large plant; indeed, the length of the valley and its limited width seem to render the latter idea impracticable.

The price of gasoline at various points in the valley is rather high at present, and it may prove more profitable to use coal in producer-gas plants or steam engines than to rely upon petroleum products for fuel.

The discovery that the water in the valley of Birdwood Creek has considerable artesian head may prove to be of great value to lands near North Platte. Lands near Birdwood Creek, except those in a narrow valley strip, consist of sand hills which have little agricultural value, but by sinking a number of 12-inch wells to a depth of about 100 feet along the west fork of Birdwood Creek, the low-stage flow of the stream could be nearly doubled and water could be taken from the creek near its mouth and placed upon lands in the valley of Platte River. The expense of this development of the water supply will be so slight that it could readily be left to the enterprise of private capital.

Some pumping plants are now being installed in the South Platte Valley, but good bottom lands in the district investigated are in large part still idle, and suitable immigration of people able to make the best use of the present water resources is very much to be desired. It is hoped that the pioneers will take as great pains as possible in developing the water supply so that the future of the valley will not be injured by carelessness on the part of those seeking water for present needs.

OPERATIONS IN NEVADA.

By L. H. Taylor.

In Nevada an examination of the opportunities for reclamation was begun in 1889, and general surveys were made in 1890. Stream gagings have been continued at intervals since that date under charge of L. H. Taylor. The large amount of information thus made available concerning the water resources of the State facilitated an early conclusion regarding the merits of various projects. As a result work was begun at an early date on the plans and estimates for utilizing the waters of Truckee and Carson rivers.

TRUCKEE-CARSON PROJECT.

The principal water supply for western Nevada comes from the mountains of California near the western boundary of the State. The main streams are Truckee, Carson, and Walker rivers. These converge toward the desert lands and disappear in sinks or lakes at altitudes of about 3,900 feet. Around these sinks are broad bodies of arid land, much of it of excellent quality when watered.

A number of reservoir sites on the headwaters of Truckee and Carson rivers have been surveyed and opportunities for diverting the water have been examined. The most important point at which water may be held is in Lake Tahoe, which is crossed by the State boundary, being partly in California and partly in Nevada. The outlet into Truckee River is in California, and the river continues in that State for several miles. The simplest project, from an engineering standpoint, is to utilize Lake Tahoe; but owing to the legal difficulites it has not been deemed wise to begin at the upper end of the river.

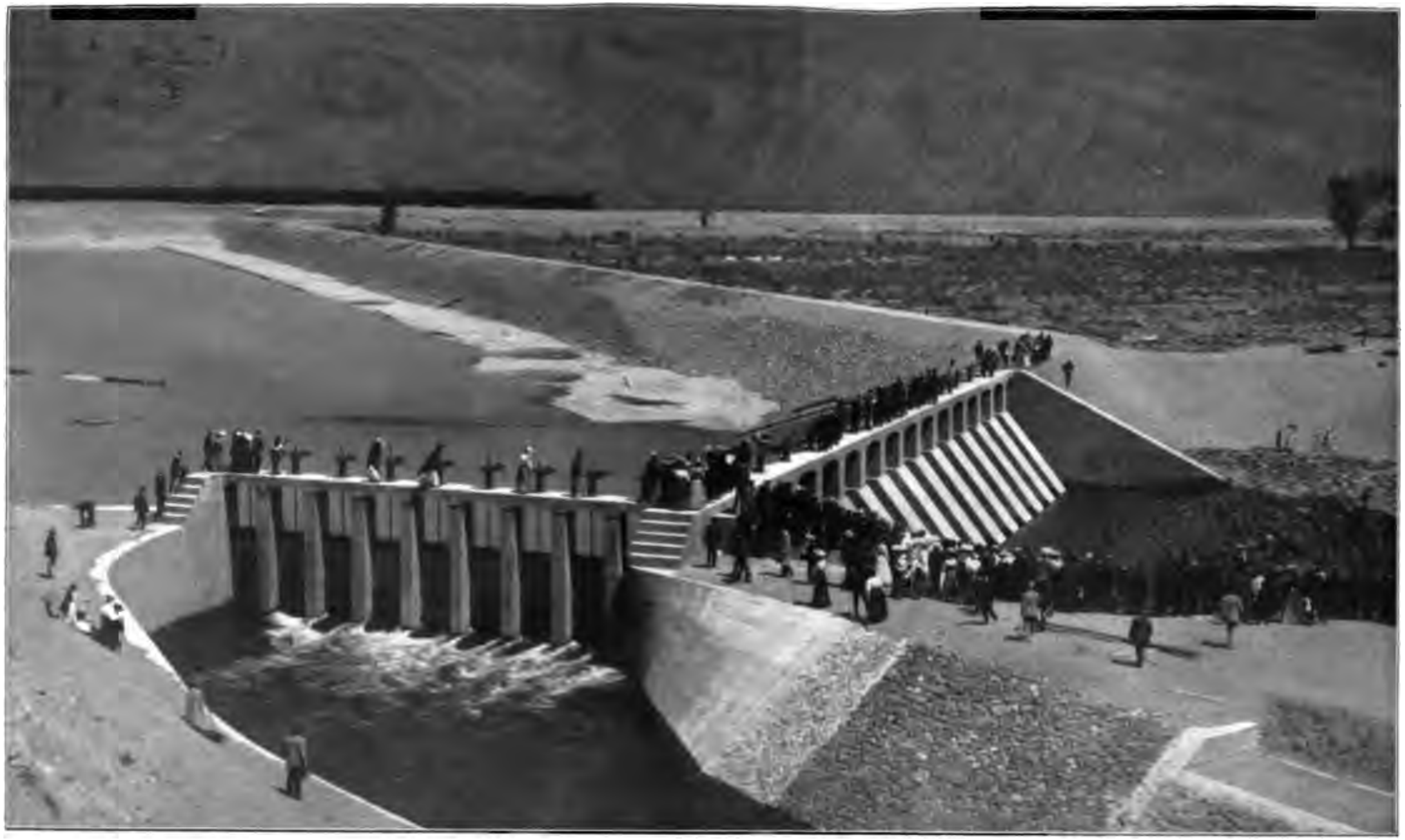
The waters of Truckee River are used for the irrigation of lands in the vicinity of Reno. Below these lands the river flows through a narrow canyon and then turns to the north, its waters being lost in Pyramid and Winnemucca lakes. In this lower canyon a canal has been constructed to take out the flood and excess waters of Truckee River, which would otherwise be lost in the lakes, and carry them southeastward to a reservoir site on the lower part of Carson River. In this same reservoir the excess waters of the latter stream can also be used. From this reservoir distributing canals can be built to cover several hundred thousand acres of land near Carson Sink.

MAIN TRUCKEE CANAL.

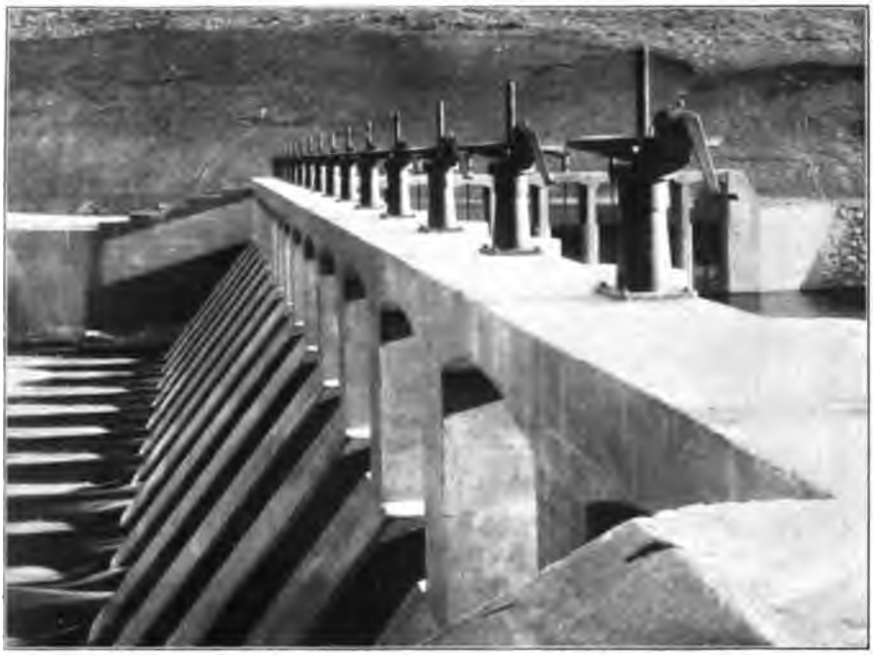
Plans and estimates made by L. H. Taylor were submitted to a board of consulting engineers, consisting of Messrs. Wisner, Davis, and Quinton, and approved by them in May, 1903. Bids were opened in July, 1903, for the construction of the canal from Truckee River, the work consisting of three divisions. A contract was entered into August 28, 1903, with E. B. & A. L. Stone Company to construct division 3 of the canal, and September 3, 1903, with C. A. Warren & Co. to construct divisions 1 and 2.

MAIN DISTRIBUTING CANALS.

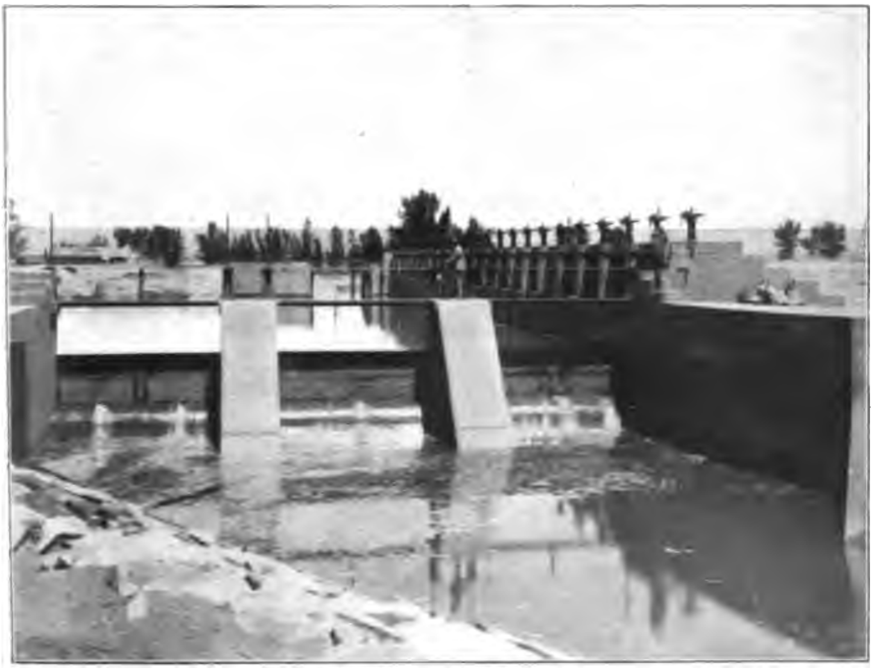
It is proposed to divert water from Carson River at a point about 5 miles below the lower Carson reservoir site by means of two main canals, that on the south side of the river having a capacity of 1,500 second-feet, and that on the north side about 450 second-feet. These canals, with their main branches, will traverse Carson Sink Valley and constitute the main distributing system for about 200,000 acres of land.



DIVERSION DAM ON TRUCKEE RIVER, TRUCKEE-CARSON PROJECT, NEVADA.



A. DIVERSION DAM AND GATES ON TRUCKEE RIVER, TRUCKEE-CARSON PROJECT, NEVADA



B. HEADWORKS OF DISTRIBUTING SYSTEM ON CARSON RIVER, TRUCKEE-CARSON PROJECT, NEVADA.

Plans and estimates made by L. H. Taylor were submitted to a board of consulting engineers, consisting of Messrs. Quinton, Sanders, and Savage, and approved by them April 15, 1904; the recommendation was approved by the Secretary May 24, 1904. Proposals for the construction of 37 miles of the main distributing canals, with diverting dam, regulating gates, spillways, falls, weirs, and bridges, were opened at Reno, Nev., July 15, 1904. Contracts for this work were awarded as follows:

Earthwork, about 1,500,000 cubic yards excavation, to Pacific Coast Construction Company, of Portland, Oreg.; contract dated September 9, 1904.

Headworks, to R. C. Mattingly, of San Francisco, Cal.; contract dated September 29, 1904.

Falls, lateral head-gates, spillways, etc., to San Francisco Construction Company, of San Francisco, Cal.; contract dated September 17, 1904.

Bridges, to C. W. Swain, of Ione, Cal.; contract dated August 19, 1904.

LATERAL DISTRIBUTION SYSTEM.

The irrigable lands in Carson Sink Valley have been divided into six separate districts. Each district comprises from 25,000 to 50,000 acres, and will be reclaimed by a system of lateral distributaries supplied with water from the above main distributing system, with the requisite waste ditches. It is proposed to close two of the three branches into which Carson River divides, and to improve the third (Old Carson River) channel to convey the surplus or flood waters to Carson Sink. The general plan for the project also contemplates utilizing a drop of 26 feet in the main south-side distributing canal to develop power for pumping water to lands along the border of the valley too high to be reached by gravity ditches. For this purpose it is proposed, in connection with the construction of the fall, to build the foundation of the necessary power house preparatory to the future installation of machinery.

Plans and estimates made by L. H. Taylor for the lateral and waste ditches for portions of districts 1 and 2 part of the Carson River old-channel canal and the 26-foot fall and power-house foundation were approved by a board of consulting engineers, consisting of Messrs. Quinton, Sanders, and Davis. Proposals for construction were opened at Hazen, Nev., December 15, 1904, the work being divided into six parts. Contracts were awarded as follows:

Divisions 1, 2, and 6, to San Francisco Construction Company, of San Francisco, Cal.; contract dated February 3, 1905.

Divisions 3 and 4, to Utah Construction Company, of Ogden, Utah; contract dated February 10, 1905.

Division 5, to Pacific Coast Construction Company, of Portland, Oreg.; contract dated February 21. 1905.

Bids received for the construction of lateral ditches with structures and Carson River old-channel canal.

DIVISION 1.

Work.	Quantity.	San Francisco Construction Co., 26 Montgomery street, San Francisco, Cal.		Utah Construction Co., Ogden, Utah.		D. E. Brown, Rialto Building, San Francisco, Cal.		Pacific Coast Construction Co., Portland, Oreg.		W. F. Beard & Co., Modesto, Cal.		Knowlton-Bollen Construction Co., Fort Collins, Colo.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:													
Class 1 ... cubic yards..	150,000	$0.13½	$20,250.00	$0.15	$22,500.00								
Class 2 ...		.45		.35									
Overhaul ... cubic yards..	1,000	.01½	15.00	.02	20.00								
Turn-outs:													
Concrete ... do....	105	10.50	1,102.50	12.00	1,260.00								
Cast iron ... pounds..	2,100	.08½	178.50	.09	189.00								
Lumber ... feet B. M..	29,000	45.00	1,305.00	42.00	1,218.00								
Paving ... square yards..	1,500	1.50	2,250.00	.50	750.00								
Puddling ... cubic yards..	200	2.00	400.00	.60	120.00								
23 bridges:													
Clear lumber ... feet B. M..	14,500	65.00	942.50	50.00	725.00								
Common lumber ... do....	28,000	45.00	1,260.00	42.00	1,176.00								
Concrete ... cubic yards..	50	10.50	525.00	12.00	600.00								
Total ...			28,228.50		28,558.00								

DIVISION 2.

Work.	Quantity.	San Francisco Construction Co., 26 Montgomery street, San Francisco, Cal.		Utah Construction Co., Ogden, Utah.		D. E. Brown, Rialto Building, San Francisco, Cal.		Pacific Coast Construction Co., Portland, Oreg.		W. F. Beard & Co., Modesto, Cal.		Knowlton-Bollen Construction Co., Fort Collins, Colo.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:													
Class 1 ... cubic yards..	300,000	$0.13½	$40,500.00	$0.15½	$46,500.00								
Class 2 ...		.45		.35									
Overhaul ... cubic yards..	4,000	.01½	60.00	.02	80.00								

73 turn-outs:													
Concrete.......do....	350	10.50	3,675.00	12.00	4,200.00								
Cast iron.......pounds..	5,200	.08½	442.00	.09	468.00								
Lumber.......feet B. M..	52,000	45.00	2,340.00	42.00	2,184.00								
Paving.......square yards..	3,200	1.50	4,800.00	.50	1,600.00								
Puddling.......cubic yards..	260	2.00	520.00	.60	156.00								
29 bridges:													
Clear lumber.......feet B. M..	20,000	65.00	1,300.00	50.00	1,000.00								
Common lumber.......do....	38,000	45.00	1,710.00	42.00	1,596.00								
Concrete.......cubic yards..	70	10.50	735.00	12.00	840.00								
Total.......			56,062.00		58,024.00								

DIVISION 3.

Excavation:													
Class 1.......cubic yards..	250,000	$0.13½	$33,750.00	$0.14	$35,000.00								
Class 2.......		.45		.35									
Class 3.......		.75		.50									
Class 4.......		1.00		1.25									
Overhaul.......cubic yards..	3,000	.01½	45.00	.02	60.00								
91 turn-outs:													
Concrete.......do....	208	10.50	2,184.00	12.00	2,496.00								
Cast iron.......pounds..	4,200	.08½	357.00	.08½	357.00								
Lumber.......feet B. M..	72,000	45.00	3,240.00	40.00	2,880.00								
Paving.......square yards..	3,400	1.50	5,100.00	.50	1,700.00								
Puddling.......cubic yards..	380	2.00	760.00	.60	228.00								
30 bridges:													
Clear lumber.......feet B. M..	19,000	65.00	1,235.00	50.00	950.00								
Common lumber.......do....	39,000	45.00	1,755.00	40.00	1,560.00								
Concrete.......cubic yards..	72	10.50	756.00	12.00	864.00								
Total.......			49,182.00		46,095.00								

Bids received for the construction of lateral ditches with structures and Carson River old-channel canal—Continued.

DIVISION 4.

Work.	Quantity.	San Francisco Construction Co., 26 Montgomery street, San Francisco, Cal.		Utah Construction Co., Ogden, Utah.		D. E. Brown, Rialto Building, San Francisco, Cal.		Pacific Coast Construction Co., Portland, Oreg.		W. F. Beard & Co., Modesto, Cal.		Knowlton-Bollen Construction Co., Fort Collins, Colo.	
		Unit price.	Amount.	Unit price.	Amount	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:													
Class 1 ... cubic yards..	400,000	$0.13½	$54,000.00	$0.14	$56,000.00			$0.15	$60,000.00				
Class 2		.45		.35				.25					
Class 3		.75		.50				.35					
Class 4		1.00		1.25				.80					
Overhaul ... cubic yards..	10,000	.01½	150.00	.02	200.00			.01	100.00				
100 turn-outs:													
Concrete ... do....	260	10.50	2,730.00	12.00	3,120.00			12.50	3,250.00				
Cast iron ... pounds..	5,200	.08½	442.00	.08½	442.00			.11	572.00				
Lumber ... feet B. M..	77,000	45.00	3,465.00	40.00	3,080.00			37.50	2,887.50				
Paving ... square yards..	4,000	1.50	6,000.00	.50	2,000.00			1.25	5,000.00				
Puddling ... cubic yards..	400	2.00	800.00	.60	240.00			.25	100.00				
58 bridges:													
Clear lumber ... feet B. M..	36,000	65.00	2,340.00	50.00	1,800.00			37.50	1,350.00				
Common lumber ... do....	77,000	45.00	3,465.60	40.00	3,080.00			35.00	2,695.00				
Concrete ... cubic yards..	140	10.50	1,470.00	12.00	1,680.00			12.50	1,750.00				
Total			74,862.00		71,642.00				77,704.50				

DIVISION 5.

Excavation:														
Class 1..................cubic yards..	290,000	$0.15½	$44,950.00	$0.16	$46,400.00	....	....	$0.15	$43,500.00	$0.1685	$48,865.00	$0.17	$49,300.00
Class 2..................................	....	.40	....	.35	....	....	....	.25	....	.1685	....	.28	....
Overhaul..................cubic yards..	5,000	.01½	75.00	.02	100.00	....	....	.01	50.00	.00½	25.00	.01½	75.00
Total..................................	....	....	45,025.00	....	46,500.00	....	....	....	43,550.00	....	48,890.00	....	49,375.00

DIVISION 6.

Excavation:													
Class 1..................cubic yards..	3,000	$0.15	$450.00	....	....	$0.60	$1,800.00	....	....	....	....	....	....
Class 2..................................	....	.50	....	....	....	.75	....	....	....	....	....	....	....
In trench..............cubic yards..	1,000	.35	350.00	....	....	1.00	1,000.00	....	....	....	....	....	....
Back filling.........................do....	2,000	.20	400.00	....	....	.50	1,000.00	....	....	....	....	....	....
Puddling............................do....	1,000	2.00	2,000.00	....	....	2.00	2,000.00	....	....	....	....	....	....
Paving.....................square yards..	600	2.00	1,200.00	....	....	2.50	1,500.00	....	....	....	....	....	....
Concrete....................cubic yards..	3,260	12.00	39,120.00	....	....	14.00	45,640.00	....	....	....	....	....	....
Cast iron.........................pounds..	7,400	.09	666.00	....	....	.10	740.00	....	....	....	....	....	....
Steel I-beams.......................do....	8,800	.09	792.00	....	....	.08	704.00	....	....	....	....	....	....
1½ G. P. railing in place.............feet..	68	.40	27.20	....	....	.35	23.80	....	....	....	....	....	....
Clear O. P. lumber............feet B. M..	4,000	68.00	272.00	....	....	50.00	200.00	....	....	....	....	....	....
Total..................................	....	....	45,277.20	....	....	....	54,607.80	....	....	....	....	....	....

PRESENT CONDITION OF WORK.

Work under all the contracts above enumerated has been completed, except that of the San Francisco Construction Company on divisions 1 and 2 of lateral canals, of the Utah Construction Company on division 4 of lateral canals, and of Edward Malley on the Tahoe outlet and regulating works. The first two of these contracts are, however, rapidly approaching completion.

About 75 miles of lateral and waste ditches have been constructed on force account. This work is still progressing in a satisfactory manner and at a considerable saving over similar work done by contract.

Topographic mapping of all irrigable lands in the various valleys under the Truckee-Carson project was completed early in the summer. Views of the completed works on the Truckee-Carson project are shown on Pls. XXXIX-XLIII.

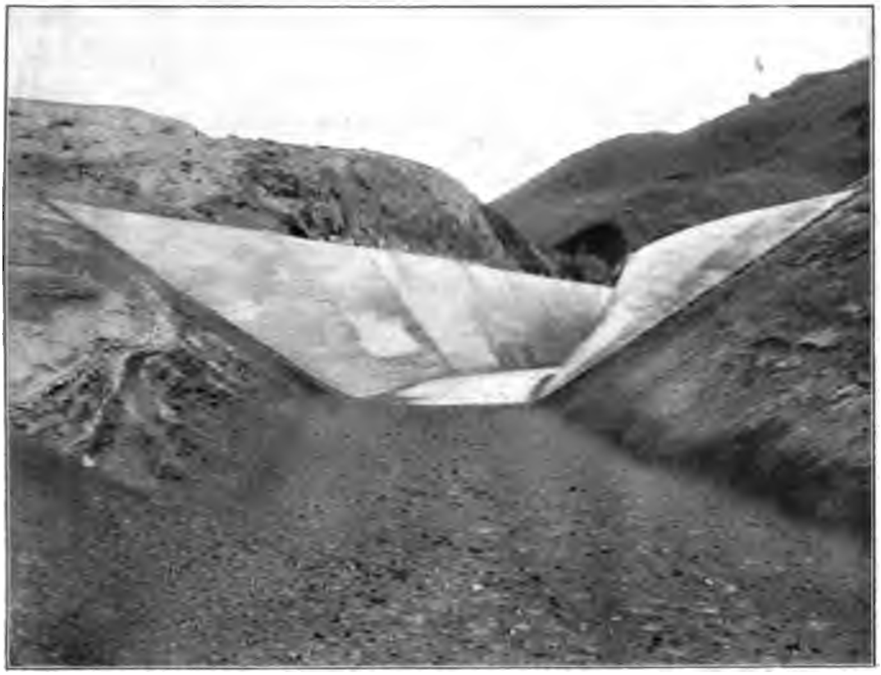
LAKE TAHOE STORAGE RESERVOIR.

Work on the Truckee-Carson project having progressed to the point of actually supplying water for irrigation, it became necessary, in order to insure an adequate supply during the season of 1906, to begin the construction of storage reservoirs. Of the available reservoir sites having sufficient capacity, Lake Tahoe is the cheapest and easiest to utilize. Accordingly plans and estimates were prepared by L. H. Taylor, submitted to a board of consulting engineers, and approved by them April 3, 1905. The recommendation was approved by the Secretary April 29, 1905. Proposals for construction of the Lake Tahoe outlet and controlling works and bridge (Pls. XLIV and XLV) were opened at Hazen, Nev., June 15, 1905.

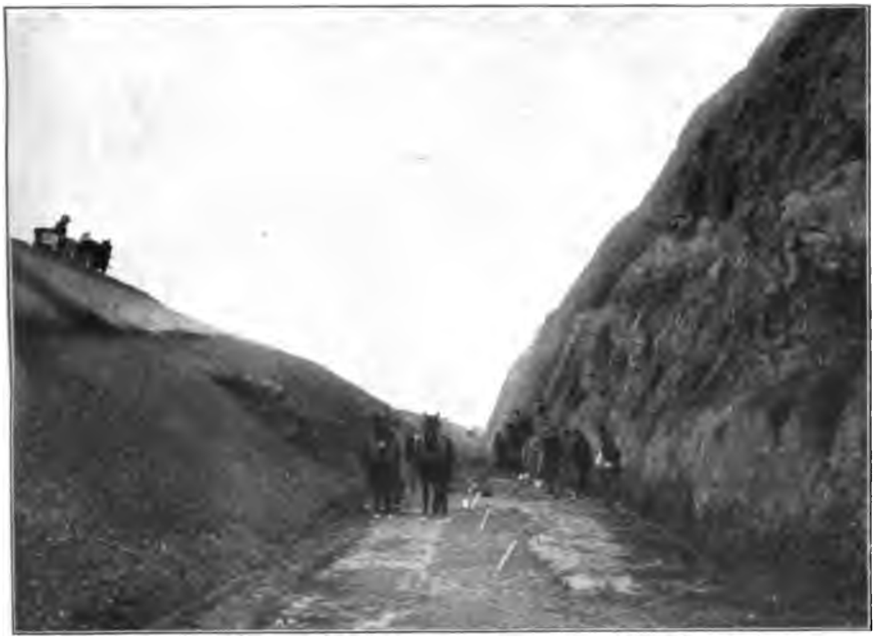
Bids received for the construction of Lake Tahoe outlet and regulating works, Truckee-Carson project, Nevada.

Work.	Quantity.	Edward Malley, Rialto Building, San Francisco, Cal.		Burrell Construction Co., Oakland, Cal.		Cotton Bros. & Co., Oakland, Cal.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:							
Class 1.......cubic yards..	90,000	$0.25	$22,500.00	$\$0.17\frac{9}{10}$	$16,110.00	$0.23½	$21,150.00
Class 2..............do....	1,000	.50	500.00	.49	490.00	.90	900.00
Class 3..............do....	100	1.00	100.00	1.50	150.00	.50	50.00
Class 4..............do....	100	1.50	150.00	1.90	190.00	1.00	100.00
Overhaul................do....	1,000	.04	40.00	.02½	25.00	.01½	15.00
Concrete................do....	500	10.00	5,000.00	14.90	7,450.00	10.00	5,000.00
Paving.........square yards..	1,000	1.00	1,000.00	1.90	1,900.00	1.00	1,000.00
Flashboard with hooks 3″ by 12″ by 5′ 4″..................	160	1.00	160.00	1.25	200.00	.50	80.00
Flashboard without hooks 2″ by 8″ by 5′ 4″................	40	.25	10.00	1.00	40.00	.25	10.00
Foot planks 3″ by 12″ by 14′ 0″.	10	1.00	10.00	1.50	15.00	.80	8.00
Cast iron.............pounds..	8,000	.07	560.00	.08	640.00	.05	400.00
Steel in place in concrete.do....	1,000	.07	70.00	.16	160.00	.10	100.00
Puddling........cubic yards..	100	1.00	100.00	1.90	190.00	.65	65.00
Dredging in lake........do....	5,000	.40	2,000.00	1.00	5,000.00	1.20	6,000.00
Total bid..................	....	....	32,200.00	....	32,560.00	(a)	a 34,878.00

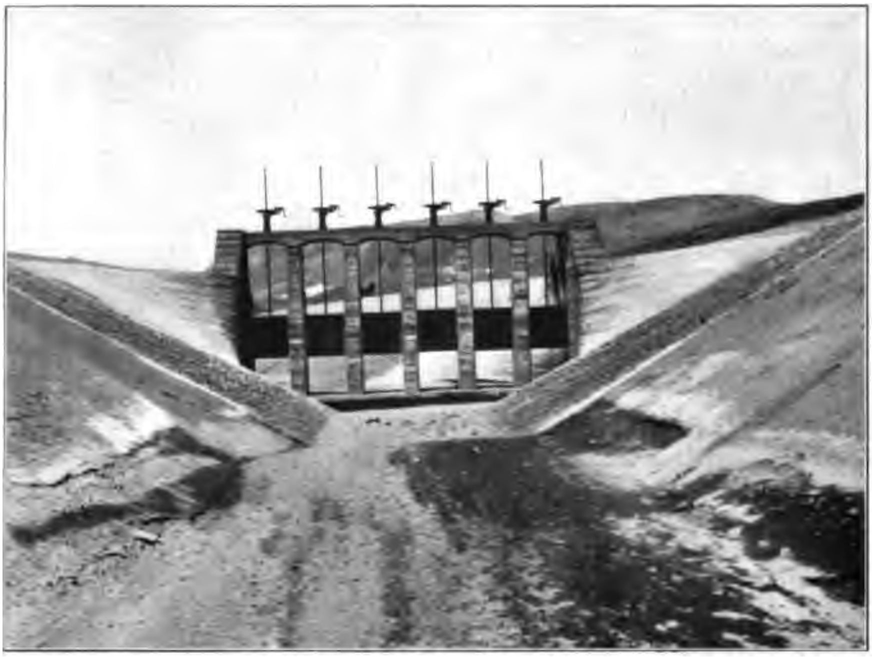
a Basis of bid: Entire schedule.



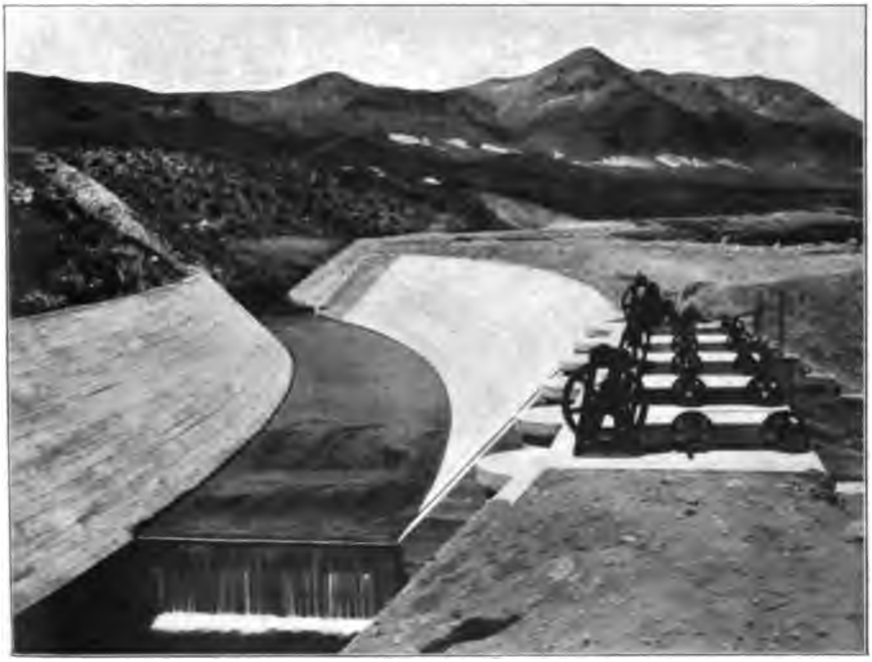
A. COMPLETED PORTION OF CEMENT-LINED CANAL BELOW THE EAST END OF TUNNEL 7, DIVISION 2, TRUCKEE-CARSON PROJECT, NEVADA.



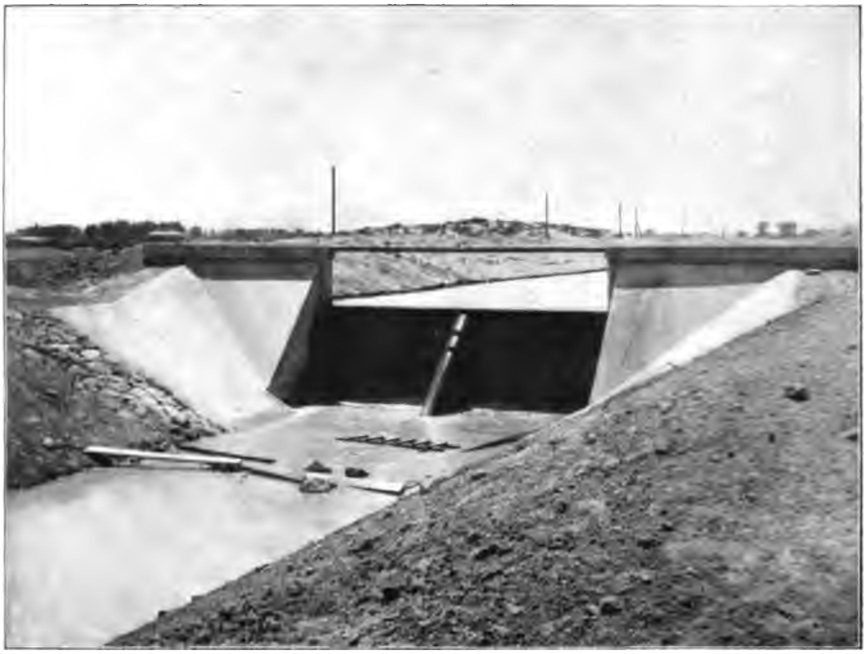
B. ROCK CUT, TRUCKEE CANAL, TRUCKEE-CARSON PROJECT, NEVADA.



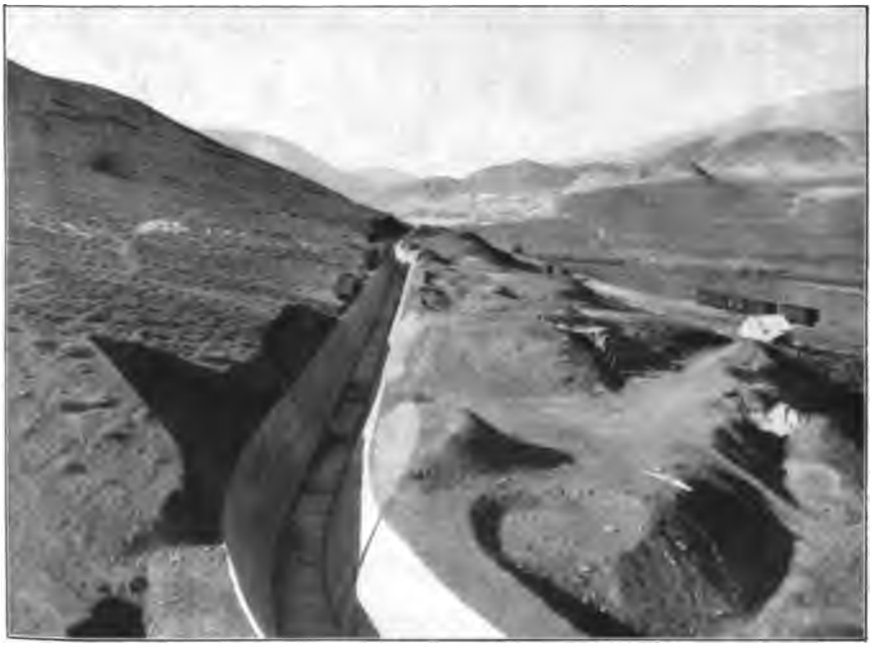
A. COMPLETED GATES AT THE PYRAMID TAKE-OUT, MAIN TRUCKEE CANAL, TRUCKEE-CARSON PROJECT, NEVADA.



B. DROP AT DERBY WASTEWAY AND TOP OF WASTEWAY GATES, TRUCKEE-CARSON PROJECT, NEVADA.



A. DROP IN "L," TWO-LINE CANAL, TRUCKEE-CARSON PROJECT, NEVADA.



B. VIEW WEST OF TRUCKEE CANAL FROM TOP OF TUNNEL 2, DIVISION 2, TRUCKEE-CARSON PROJECT, NEVADA.

Showing completed portion of cement-lined canal.

Bids received for the construction of Lake Tahoe outlet and regulating works, Truckee-Carson project, Nevada—Continued.

Work.	E. B. & A. L. Stone, Oakland, Cal.		William Degen, Fresno, Cal.				City Street Improvement Co., 512 Mills Building, San Francisco, Cal.	
	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Excavation:								
Class 1	$0.35	$31,500.00	$0.40	$36,000.00	$0.45	$40,500.00	$0.79	$71,100.00
Class 2	.75	750.00	.50	500.00	.55	550.00	.85	850.00
Class 3	1.00	100.00	.70	70.00	.75	75.00	1.00	100.00
Class 4	1.25	125.00	.95	95.00	1.00	100.00	1.00	100.00
Overhaul	.02	20.00	.01½	15.00	.01½	15.00	.05	50.00
Concrete	12.00	6,000.00	11.00	5,500.00	14.00	7,000.00	8.10	4,050.00
Paving	1.50	1,500.00	2.50	2,500.00	4.00	4,000.00	2.75	2,750.00
Flashboard with hooks 3″ by 12″ by 5′ 4″	1.00	160.00	1.30	208.00	2.50	400.00	1.30	208.00
Flashboard without hooks 2″ by 8″ by 5′ 4″	.50	20.00	.40	16.00	1.00	40.00	.90	36.00
Foot planks 3″ by 12″ by 14′ 0″	1.75	17.50	2.50	25.00	5.00	50.00	2.50	25.00
Cast iron	.06	480.00	.08	640.00	.08	640.00	.10	800.00
Steel in place in concrete	.06	60.00	.06	60.00	.06	60.00	.10	100.00
Puddling	1.50	150.00	.40	40.00	.40	40.00	.20	20.00
Dredging in lake	2.00	10,000.00	1.20	6,000.00	4.50	22,500.00	1.97	9,850.00
Total bid	(a)	[a]50,882.50	(a)	[a]51,669.00	(b)	[b]75,970.00	(a)	[a]90,039.00

[a] Basis of bid: Entire schedule.

[b] Basis of bid: Separate items.

A contract for construction, dated July 5, 1905, was awarded to Edward Malley, of San Francisco, Cal. The contractor began work early in August, but was stopped August 21 by an injunction issued by a State court of California at the instance of a property owner on the shore of the lake, who claims that the plans of the Government wlil work an injury to his property.

Owing to the impracticability of completing the location and plans for a portion of the lateral-distribution system necessary to supply water to a number of farms having old water rights, as well as to a portion of the arable lands in district No. 1, in time to obtain proposals and award contracts for their completion during the current year, the construction of about 100 miles of lateral and waste ditches was undertaken on force account.

A more detailed examination and classification of the irrigable lands in Carson Sink Valley was begun in July and is well under way. The lands in district No. 3 have been subdivided into farms unit and maps thereof are being made.

Early in the summer two engineering parties began the location of lateral and drainage ditches in district No. 3, and recently two similar parties have been placed on like work in each of districts 4 and 5. Plans and estimates are now in preparation on which to invite proposals for the construction of a portion of these ditches.

Preparations are being made to begin diamond drilling at Alkali Flat reservoir site, on Carson River, as well as at a number of dam sites on the headwaters of that stream and Truckee River.

Under the contract with J. D. Spreckels & Bros. Company for supplying cement, 35,223 barrels of cement were purchased at $2.55 per barrel. A contract was then entered into with the Pacific Portland Cement Company, of San Francisco, Cal., for 10,000 barrels, f. o. b Tolenas, Cal., at $1.50 per barrel. This having been completed, proposals for 2,500 barrels additional were opened on July 25, 1905. The bid of the Pacific Portland Cement Company being the lowest ($1.50 per barrel f. o. b. Tolenas, Cal.), was accepted and deliveries are now being made by that firm.

The construction of a telephone system, connecting different parts of the work, by force account, is progressing satisfactorily and about 65 miles are completed.

EXPENDITURES.

The expenditures to September 30, 1905, were as follows:

Expenditures on Truckee-Carson project to September 30, 1905.

Main canal and dam:		
Excavation—		
C. A. Warren & Co	$949,758.33	
E. B. & A. L. Stone Company	339,118.80	
		$1,288,877.13
Distributing canals:		
Excavation, Pacific Coast Construction Company	254,777.26	
Headworks, R. C. Mattingly	60,773.13	
Head-gates, San Francisco Construction Company	53,947.76	
Bridges—		
C. F. Swain	2,040.00	
Force account	1,200.00	
		372,738.15
Lateral ditches, excavations:		
San Francisco Construction Company	92,778.86	
Pacific Coast Construction Company	43,436.31	
Utah Construction Company	77,529.71	
Force account	125,000.00	
		338,744.88
Telephone line, force account		5,600.00
Office buildings, quarters, corrals, storehouses, and shops		45,000.00
Cement:		
Spreckels & Bros. Company	89,818.65	
Pacific Portland Cement Company	15,021.00	
		104,839.65
Purchase of lands		37,617.00
Preliminary examination		6,700.00
Final surveys, design, etc		106,000.00
Engineering and inspection on construction		112,000.00
Administration and operation		80,005.49
Total		2,498,122.30

WALKER RIVER PROJECT.

At the instance of the farmers in the valley of Walker River, who are involved in litigation over their water rights on account of the insufficiency of the supply for irrigation in the latter part of the season, the Secretary authorized an investigation of the feasibility of storing enough of the flood waters to provide an ample supply to all lands now under cultivation and irrigation. A reservoir site for this purpose was carefully examined and found to be economical of construction, but the land owners have thus far failed to organize a water-users' association, and take the other necessary steps in compliance with the terms of the reclamation act, which are a condition requisite to the commencement of construction. In the meantime, in cooperation with the State engineer, all the irrigated and irrigable lands, together with two other reservoir sites, are being surveyed and mapped on a scale of 1,320 feet to the inch, with contour interval of 5 feet. This work will probably be completed during November.

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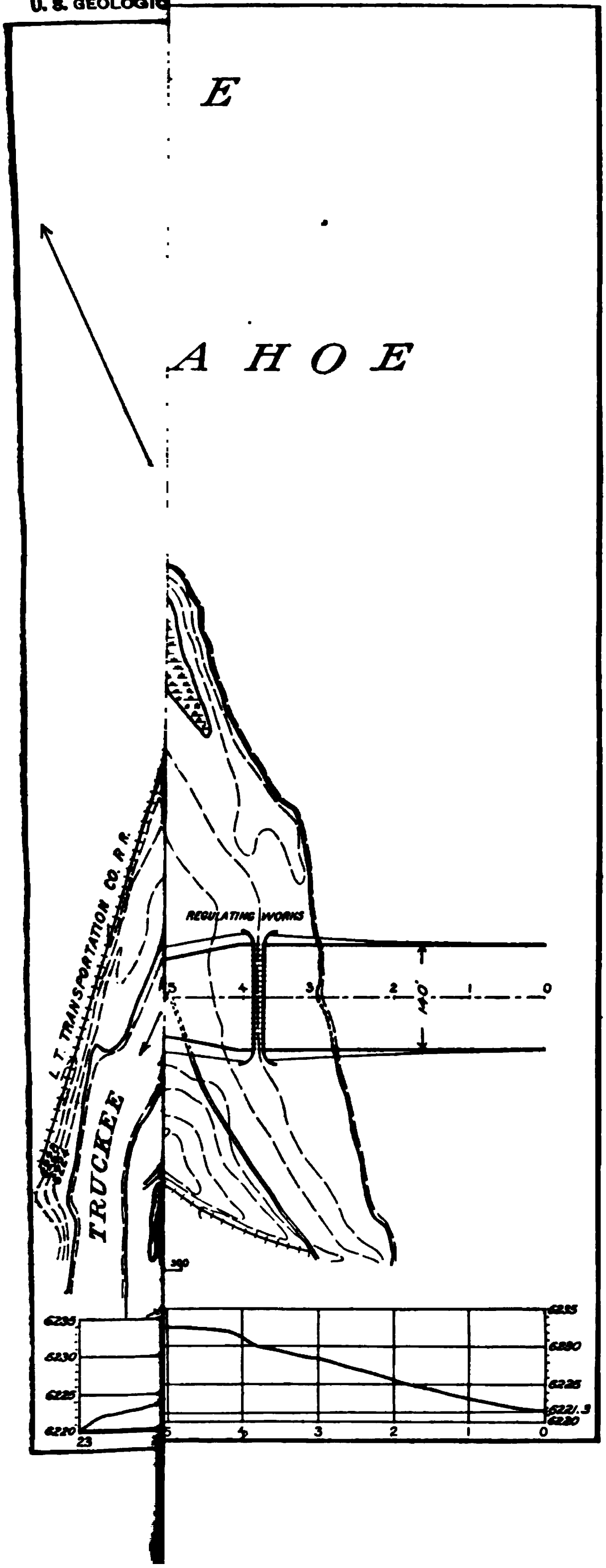

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HUMBOLDT RIVER PROJECT.

In September a general study of the irrigation possibilities in the basin of Humboldt River ras begun and is now being carried on.

RECONNAISSANCE SURVEYS.

Reconnaissance surveys have been carried on along important streams in Nevada, largely n cooperation with the State engineer. Measurements of important streams are also being nade in cooperation with him, and facts concerning the character and extent of present vater rights are being ascertained. Studies of evaporation at Lake Tahoe and other points in the basins of Truckee and Carson rivers are also being made

OPERATIONS IN NEW MEXICO.

By B. M. Hall.

CARLSBAD PROJECT.[a]

The Carlsbad project contemplates the furnishing of water to about 20,000 acres of land that are under the irrigation system of the Pecos Irrigation Company. These lands have been irrigated, but a series of accidents to the works of the company made the delivery of water uncertain and produced a condition that it felt unable to remedy in a permanent manner. In order to prevent the cultivated lands again becoming desert, the Reclamation Service was asked to take over the works and put them in proper condition. Investigations were begun by the Service in January, 1905, and are now in progress.

EXISTING IRRIGATION SYSTEM.

The reservoirs and canal system of the Pecos Irrigation Company are shown on the accompanying general map (Pl. XLVI). Two reservoirs have been constructed by this company and its predecessors—Lake McMillan, the storage reservoir, and Lake Avalon, the distributing reservoir. The general plan of construction was the same, the reservoir in each case being formed by a high long dam across the stream channel at a point where the valley is narrowed by limestone bluffs. The dam at Lake McMillan has a crest length of 1,686 feet and a maximum height of 52 feet, and the dam at Lake Avalon was 1,380 feet long and had a maximum height of 50 feet. The cross sections of the two dams were closely similar. At Lake McMillan the downstream portion of the dam consists of a rock fill with downstream slope of 1½ to 1, upstream slope ½ to 1, and top width of 6 feet. The upstream portion of the dam is of earth, with a water slope of 3½ to 1 and a crest width of 14 feet. The water face is paved with about 18 inches of broken stone, apparently hand laid and sledged to place. The crown of the embankment is 10 feet higher than the maximum proposed flow line, 25 feet above the gate sill. On the water face a portion of the bank, followed by the riprap, has broken down, assuming a slope of about 5 to 1, estimated.

When constructed this reservoir had a total storage capacity of 80,000 second-feet, and when full submerged 8,331 acres. In order to bring it up to this capacity an embankment about 5,200 feet in length and with a maximum height of 18.8 feet was built across a low-lying piece of ground to the west of the main dam. It is uncertain that the reservoir was ever filled to its utmost capacity, and at present, for reasons which will be discussed later, the storage capacity has become very greatly reduced.

This reservoir is provided with an outlet canal on the east side of the river, cut through a very poor quality of rock and leading back into the river at a point about 300 feet below the head-gates. These gates, six in number, are of wood, 4 feet wide by 8 feet high, with a clear opening of about 3 feet 4 inches, and are raised by iron screws operated by hand. As originally planned a spillway was built between the east end of the dam and the gates, the water returning to the river very close to the outlet canal and to the lower toe of the dam. This, however, was considered a danger point and was abandoned and blocked. The spillway used at ordinary flood stages is cut through rock about 1 mile west of the end on the dam, the water discharging into an arroyo which delivers it into the river at a point about 2 miles below. In addition to this a cut has been made in the bank still farther west to serve as a spillway, discharging eventually into the same arroyo as the spillway last mentioned. The water has been cutting back from the discharge end at this point and has now cut back

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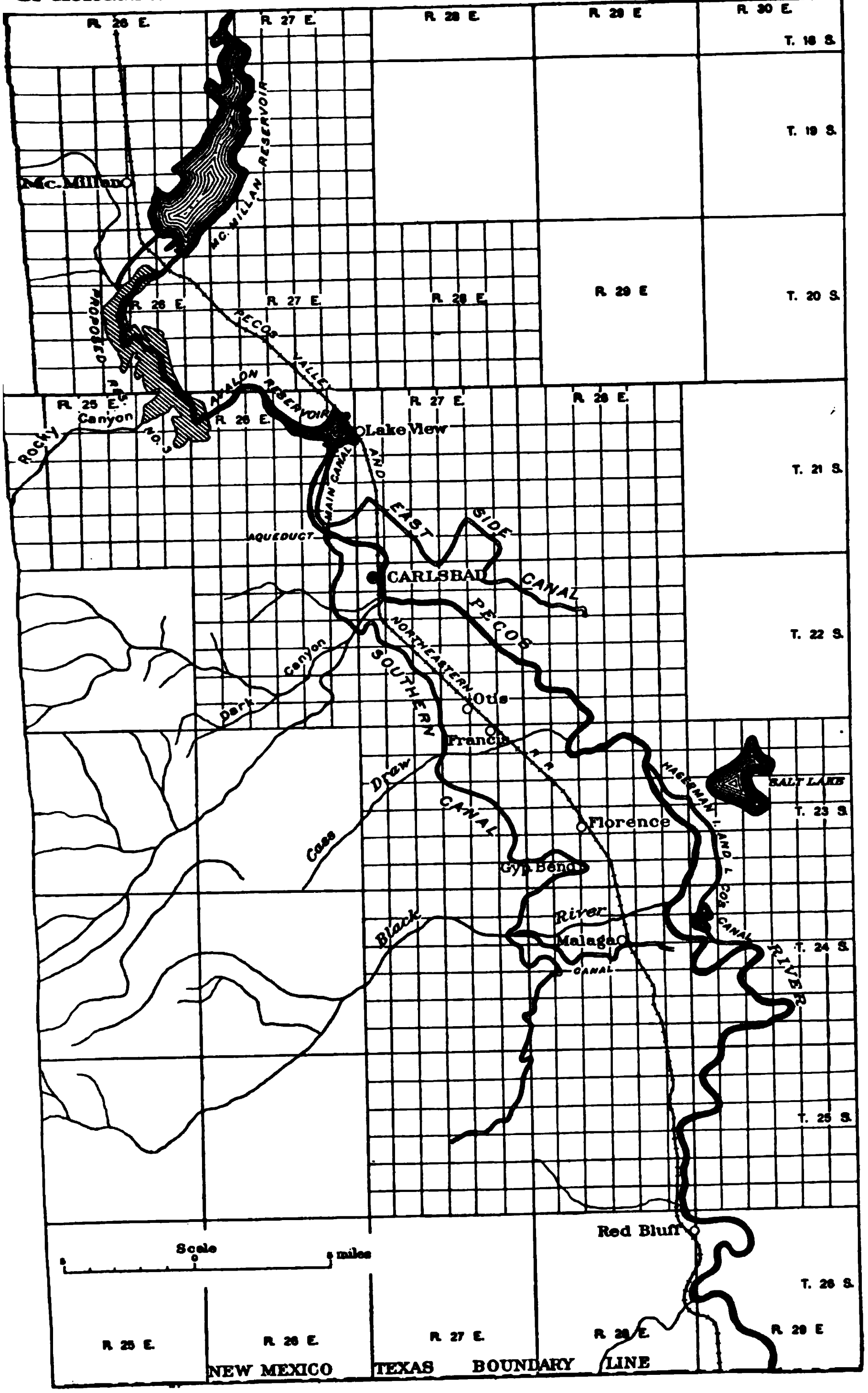
[a] From report by E. W. Myers.



GENERAL MAP OF CARLSBAD PROJECT, NEW MEXICO.

o the bank. A few more large floods will probably turn the river channel through this oint, emptying the reservoir unless some preventive work is done at an early date.

The dam at Lake Avalon was very similar to that at Lake McMillan. This reservoir as onstructed is stated to have had a capacity of 6,300 acre-feet and to have submerged ,980 acres. It is no longer in existence, as the dam was destroyed by the flood of Octo-er, 1904.

The canal had a bottom width at the reservoir of 45 feet, with a bank on the lower or river side, side slopes of 1½ to 1 and a berm of 5 feet between excavation and embankment, the crown of the bank being 8 feet above canal grade. The grade of the canal was 1.5 feet in 5,000. There was no upper bank to the canal, in order, as stated, that storm waters might have easy access; spillways were put in the lower bank for the purpose of disposing of the surplus water.

The canal divides at a point about 3 miles below the head-gates, one branch, known as the east-side canal, watering the suburb of La Huerta and Hagerman Heights, and extending for some 20 miles below its intake.

The main or southern canal, with a bottom width of 25 feet, crosses the river by an enormous concrete aqueduct consisting of four arched spans of 100 feet each, and serves all the land on the west side above Black River. From the aqueduct to Dark Canyon, a distance of about 3 miles, the canal passes through a sandy loam and loose broken limestone and conglomerate, and there is here some loss from seepage, indicated by additional water in springs and by saturated lands below the canal. The bottom of Dark Canyon where the canal crosses is a mass of coarse gravel and bowlders. As elsewhere, the canal is single banked, the embankment on the lower side having been provided with a timber spillway, now destroyed, to pass the floods to which the canyon is subject, while a bulkhead prevents the entrance of too great quantities of water into the canal below this point. There is evidently a considerable loss here, as a large area is submerged by the back water from the canal and it is said that much water finds its way beneath the embankment through the gravel.

For about 13 miles below Dark Canyon the soil is more largely clay, and though there is probably no single place where the loss is as great as at Dark Canyon, still the aggregate amount of leakage is large, as is proved by the fact that lands lying below have been rendered unfit for cultivation by the seepage waters. At "Gyp Bend," still farther down, the canal is excavated for several miles through a gypsum formation and the loss of water is enormous, reaching at times 75 per cent of the amount flowing in the canal. Three miles below this point the canal reaches Black River, which was formerly crossed by a timber flume; this, however, rotted away some years ago and has never been replaced. Instead, a low concrete dam about 70 feet long and from 2 to 4 feet high has been built across the river and from this a new canal about 3 miles long has been constructed, joining one of the larger laterals from the old canal on higher ground. The water from the canal was dropped into the river at the old flume crossing and taken out by the new canal. About 9 second-feet of water obtained from Black River are thus rendered available in addition to the amount carried by the main canal. So far as can be ascertained the high-line canal south of Black River has been used very little, if at all.

The topography of the country is such that most of the main laterals run on the land lines, the grade following the natural slope of the surface, though in some cases drops have been built, and in places the canal grade is supported on small fills.

WATER RIGHTS.

The lands of the valley have been in part owned by the Pecos Irrigation Company, in part by private individuals, and a part is still in Government ownership. To those purchasing land from the company, at prices of from $35 to $40 per acre, a deed was given attaching a permanent water right to the land for no further consideration than the payment, semiannually in advance, of a rental charge of $1.25 per acre for a delivery of 1 acre-foot, or so much thereof as might be necessary for the cultivation of a crop, this water to be delivered to the consumer at the main canal, and not at his land. The private landowner who desired to purchase a water right could do so for the sum of $10.00 per acre, on the same rental conditions as if land were purchased from the company.

At present there are in private ownership under the canals 26,375 acres of land which have water rights attached to them,[a] and the company still owns and has for sale 24,470 acres to which these water rights are attached. The location of these lands, owned by the company and by individuals, is shown on the general map (Pl. XLVI).

SOILS.

The lands lying under the Carlsbad project have been farmed for nearly fifteen years. Many farmers have failed to make a living, and many others have produced but little. Some have grown profitable crops, and have thus demonstrated the possibilities of the soil, water, and climate. The following table shows the areas of different classes of soil:

Classification of lands under Carlsbad project.

Location.	First and second classes.	Third and fourth classes.
West side of Pecos River:	*Acres.*	*Acres.*
Above Cass draw, under canal	11,900	4,400
Cass draw to Black River	15,200	9,600
Below Black River to middle of T. 24 S., under canal	1,600	4,900
South of middle of T. 24 S., under extension of canal to Salt draw	10,000	13,000
East side of Pecos River:		
Under present east-side canal	2,300	1,500
Under extension of east-side canal	6,300	10,500
Under Hagerman canal	2,000	....
Total	52,300	43,900

The first class includes all sand and sandy loam free from harmful quantity of alkali salts; if covered with dunes these must be less than 8 feet high and entail moderate expense in leveling. Land is nearly all level and can be immediately brought into profitable cultivation. Some small areas may be above canal water and will need flumes or terrepleins to permit gravity irrigation.

The second class includes all lands described under the first class which have become damaged by alkali or seepage water to such an extent as to render them unsuitable for general crops. These lands are easily drained, and from the few attempts at drainage it is evident that they can be brought back to fertility at moderate cost. There are 2,100 acres of such lands needing drainage, and surrounding them are 5,200 acres of land slightly damaged which would be greatly benefited by this drainage.

The third class includes two distinct grades—gypsum land and gravel land. The gypsum land has all been included as third class, but there is a certain percentage of land among this which on more detailed mapping can be placed as second or first class. This may amount to as much as 50 per cent of the entire amount (10,400 acres) of gypsum land, but the actual area can not be determined except by detailed examination. There is considerable doubt of the practicability of farming this gypsum land, as will be shown later. The other grade (gravel land) includes all the porous gravel lands and those under which the gravel conglomerate is near the surface. There is a large area of such land which is very porous and shallow. Irrigation water rapidly sinks out of sight and large amounts of water are required to grow a crop. This water, running through the gravel beds, comes out below, to the damage of bottom lands. At the present time irrigation of these gravel lands is not profitable, but it is thought that later these conditions may be overcome.

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[a] Since this report was written the water rights to 11,507 acres of this land have been declared to have lapsed. Valid water rights are now therefore attached to 14,868 acres of land in private ownership.

Fourth-class land includes all not irrigable. There is a certain amount of this land below the canal in the form of hills not irrigable except by an expensive terreplein or by pumping.

The total area is 96,200 acres of all classes. It will probably be inadvisable to cultivate the lands of the third and fourth classes, and with these deducted there remain 52,300 acres of land belonging to the first and second classes. Included in this, however, are 2,000 acres lying beneath the Hagerman canal, which was not included in the offer made by the Pecos Irrigation Company nor in this investigation, and this deducted leaves 50,300 acres. Of this amount 8,600 acres lie under the east side canal—2,300 acres under the canal as operated and 6,300 under the canal as constructed but not operated.

WATER SUPPLY.

In any irrigation project the total amount of water available in the source of supply, its distribution throughout the year, and its suitability for irrigation purposes are the determining factors in fixing the limits of the area which can be reclaimed, when considered in proper connection with the conditions of soil, climate, crops, and farming methods likely to be followed, all of which enter into the calculation of the duty of water.

The data concerning the flow of Pecos River presented below were obtained from two sources, those from 1891 to September 1, 1904, being obtained from the records of water passed through the headgates and over the spillways at Lake Avalon, the amounts having been computed by Mr. V. L. Sullivan, engineer of the Pecos Irrigation Company, and separately by Mr. J. M. Giles, district hydrographer. As far as possible the data for 1904 have been checked by comparison with the records of the Carlsbad gaging station, and the data for the current year are obtained from that station.

Estimated monthly discharge in acre-feet of Pecos River at Avalon dam.

	1891.	1895.	1899.[a]	1900.	1901.	1902.	1903.	1904.	1905.
January	....	....	13,527	15,739	9,636	12,977	[b] 17,321	....	[d] 20,201
February	....	....	16,697	9,099	10,955	7,734	15,521	[c] 4,762	[d] 41,814
March	....	([e])	8,641	7,993	7,425	11,907	8,424	[c] 8,724	[d] 73,811
April	....	8,985	10,240	10,155	14,161	9,828	4,688	[c] 11,310	[d] 57,748
May	....	9,897	14,777	35,428	15,853	23,766	9,934	[c] 9,290	[d] 90,562
June	[f] 15,755	20,513	12,323	26,589	17,417	20,823	79,072	[c] 5,534	[d] 69,506
July	26,925	141,997	21,908	14,901	38,678	19,171	11,331	16,540	[d] 310,790
August	13,280	89,440	21,829	24,491	8,868	43,449	12,513	[c] 14,794	....
September	51,290	23,496	14,064	67,169	10,837	31,387	4,236	....	....
October	[g] 49,100	7,155	4,781	25,725	4,663	14,559	6,118	....	....
November	....	9,080	2,338	14,765	5,203	83,967	3,068	....	....
December	....	....	14,952	5,534	9,947	15,212	1,488	....	....
	156,350	310,563	151,076	266,588	153,643	294,880	173,714	....	....

[a] No records of spillage for the years 1896, 1897, and 1898 were kept except during 1898, when 106,270 acre-feet were spilled at Lake Avalon.

[b] Gates closed at McMillan and at Avalon. During month Lake McMillan gained about 8,500 acre-feet.

[c] This is water used in irrigation. No record of spillage, if any.

[d] Estimated by deducting 80 second-feet from flow at Carlsbad.

[e] There was water either passing through gates or over spillway during March, for reservoir fell steadily, as did Lake McMillan.

[f] June 18-30, 13 days.

[g] October 1-10, 10 days.

Estimated monthly discharge of Pecos River at Carlsbad, N. Mex., for 1904.

	Acre-feet.		Acre-feet.
January	7,333	August	9,483
February	6,542	September	10,388
March	6,137	October	[a] 399,700
April	6,319	November	41,525
May	6,276	December	29,830
June	6,510		
July	7,158	The year	537,201

Estimated monthly discharge of Pecos River at Roswell, N. Mex., for 1904.

	Acre-feet.		Acre-feet.
January	19,185	August	30,008
February	10,346	September	122,631
March	3,222	October 5–7, 8–31	[a] 331,011
April	3,946	November	32,210
May	4,613	December	8,809
June	27,657		
July	36,089	The year	629,727

The records of discharge from the reservoirs maintained by the several irrigation companies operating this project are incomplete in some cases, and computations based on them are uncertain to the extent that they involve the use of coefficients whose value can not be fixed with definiteness. Even so the results are probably as good, provided the records as kept are correct, as could be obtained in any other way, but the computed discharges in some instances seem surprisingly low in view of the large area drained by the stream. There are no records of spillage for 1894 from Avalon reservoir, and there may have been none, in which case the water entering the canal would represent the total flow of the stream. Again, there are no records of spillage for 1896, 1897, and 1898, and so again there may have been none, but the records are so incomplete as to render any computation from them of the water taken into the canal open to very grave doubt, so this has not been made. This reduces the length of record to be considered to the period since 1899. During this time a large surplus was recorded in each rainy season, and it seems reasonable to conclude that some spillage must have occurred in the other years. With this fact and the length of the record in mind, the computations have been based on the lowest annual flow.

Storage capacity for the flow of more than a single year is not to be had within the limits of the present system, and it may be assumed that about 150,000 acre-feet per annum represents the annual flow of the stream so far as this project is concerned.

The total storage capacity of the possible reservoirs is as follows: Lake McMillan, gage height of 25 feet, 62,000 acre-feet; reservoir No. 3, 65,535 acre-feet;[b] Lake Avalon, 5,578 acre-feet. This gives a total capacity of 133,113 acre-feet, or, in other words, with all the reservoirs full at the beginning of an irrigating season and with no inflow that amount of water would be available for irrigation. However, there will be a flow into the reservoir system during all the period of draft—at times a very large flow, as may be seen from the preceding tables, which show as exactly as possible the amount of this inflow to be expected and give some general idea as to when it may be available.

To ascertain the draft on the reservoirs under the present methods of farming and water distribution, the records of water delivery kept by the irrigation company were examined, and the use of water in acre-feet per acre for each month of the irrigating season was tabulated for each irrigation division for the years from 1899 to 1903, inclusive. During these years the quantity of water in acre-feet per acre used in irrigation by the system as a whole was as follows:

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[a] Computed by J. M. Giles.

[b] The investigations made since this report was written have shown that this reservoir site is unsafe on account of the occurrence of large beds of gypsum in its bottom.

Water used in irrigation under Pecos Irrigation Company's system, 1899–1903.

Year.	Acre-feet per acre.	Acres irrigated.
1899	4.39	8,881
1900	3.23	8,645
1901	3.48	9,131
1902	3.02	12,018
1903	3.03	8,378

MONTHLY PERCENTAGE OF TOTAL DRAFT.

	Per cent.		Per cent.
January	0.0	August	16.8
February	.0	September	9.4
March	8.8	October	3.6
April	18.1	November	1.0
May	16.0	December	.0
June	13.8		
July	12.5		100.0

In 1899, therefore, the average use of water on all the lands was 4.39 acre-feet, ranging from 6.51 acre-feet on canal division 1 to 2.96 acre-feet on division 3. This gives an average duty in this year of 164 acres per second-foot, with a flow of twelve months used during the period between March 1 and October 1 and measured at the farm distributary. The minimum duty (in division 1) was 111 acres and the maximum (in division 3) 244 acres. If no account be taken of storage for the nonirrigating period, then the average duty of water for this year falls to 96 acres, measured at the land, as before, while the maximum duty is 154 acres.

In 1902, when the average amount used was least—being 3.02 acre-feet, with a minimum use (in division No. 3) of 1.67 acre-feet and maximum (in division No. 1) of 5.36 acre-feet—the average duty per second-foot was 239 acres, the maximum was 434 acres, and the minimum was 135 acres, all the water, as before, being measured on the land.

The following figures show the losses in the existing canal system. Those for the years 1899–1901 are taken from reports of Mr. W. M. Reed, and those for the years 1902–1904 have been compiled direct from the original records.

Amounts of water taken into the canal and used on lands under Carlsbad project, 1899–1904.

Year.	Land covered.	Taken at headgates.		Used on lands.		Loss.
	Acres.	*Acre-feet.*	*Acre-feet per acre.*	*Acre-feet.*	*Acre-feet per acre.*	*Per cent.*
1899	8,410.0	55,589.13	6.61	24,142.72	4.39	33.6
1900	8,296.0	58,022.08	6.99	24,993.46	3.23	53.8
1901	8,760.0	88,400.60	10.09	35.041.98	3.48	65.5
1902	12,018.5	78,832.00	6.56	31,234.05	3.02	54.0
1903	8,378.0	66,919.00	7.98	21,389.79	3.03	62.0

The above shows that, in 1903, out of every 100 acre-feet taken into the canal, only 38 acre-feet were available for use. As a general average, or perhaps more correctly according to the weighted averages, it was necessary to take into the canal 2.62 acre-feet for each acre-foot delivered. The gross duty of water under the canals of the Pecos Irrigation Company has been, therefore, as follows:

Duty of water under Pecos Irrigation Company's system, 1899–1903.

	Acres per second-foot.		Acres per second-foot.
1899	109	1902	110
1900	193	1903	91
1901	72		

These figures are computed as before, viz, 1 second-foot flowing continuously in the stream and used during the irrigating season.

On the success with which this leakage can be stopped depends very largely the gross duty which can be assigned to the water. If this loss can be economically brought down to 20 or 25 per cent then it seems probable that a duty of 3 acre-feet per acre may be assigned to the water entering the canal; on this basis there will be, by constructing reservoir No. 3 and rebuilding the Avalon dam, a water supply sufficient at all times for 44,000 acres of land. This seems the maximum for which first-class water rights could be assigned with certainty. It seems probable, however, that the available water supply is much greater and that during most years there is sufficient to supply a larger acreage.

DAM SITES.

Surveys for dams have been made at the old Avalon site, at a point about 2 miles above the Avalon site, and at dam site No. 3. Those at Avalon and No. 3 had in view the possibility of the construction of storage dams, while the object of the survey above the Avalon site was to develop the practicability of an overfall diversion dam to pass with safety the floods to which the river is subject, and to turn the flow of the stream into a suitable canal to be constructed between this point and the head of the present canal at Avalon. The dam-site surveys have been made throughout by plane-table methods, the horizontal control being obtained from an accurately measured base line, platted on the plane-table sheets, from which a system of plane-table triangulation was expanded to cover the area to be mapped. The vertical control was obtained from elevations determined by wye level, and the filling in was done by placing the plane-table rodman on points whose elevations differed from that of the desired contour by only one or two tenths of a foot. The scale of these surveys was 100 feet to 1 inch, and the contour interval was varied to suit the local conditions. At the Avalon site and at the diversion dam site the interval chosen was 2 feet, while at No. 3 site the interval was 2½ feet on the flat and 5 feet on the hillsides.

Numerous borings with wash and diamond drill have been made at these sites. These have shown that no satisfactory bed-rock conditions existed at the site of the proposed diversion dam, and this idea has therefore been abandoned

The borings at the Avalon site have shown conditions suitable for the construction of an earthen storage dam with impervious core wall, which has been the only type thought suitable for the location. The restoration of this dam will involve the placing of about 117,000 cubic yards of material, the construction of an impervious core wall for the entire length of the dam (about 1,025 feet), the deepening of the outlet canal, new head-gates and spill gates in the canal, and probably some work on the main spillways. Plans and estimates for the necessary work are now being prepared. When this dam is restored with its crest at the same level as that of the old dam, 30 feet above the sill of the head-gates, the available storage will be 5,578 acre-feet.

At site No. 3 the surveys have shown that an earthen dam with a maximum height of 75 feet above water level and with a length on top of 2,082 feet will be required in order that the necessary spillways be obtained. This dam would contain 588,000 cubic yards of material and would require 11,900 cubic yards of riprap. Borings at this site show the presence of beds of gypsum.

Reservoir surveys have been made on a scale of 1,000 feet to 1 inch and with a contour interval of 5 feet at the Avalon reservoir site, at site No. 3, and on Black River. The horizontal control for these surveys has been obtained from a triangulation system expanded from an accurately measured base line, the angles being observed and the quadrilaterals adjusted and computed in the usual manner. All vertical control has been obtained from lines of accurate levels run in circuits, bench marks being placed at frequent intervals for the use of the topographer. The surveys have shown that sites for large reservoirs are not to be found within the limits of the Carlsbad project. The capacity of the Avalon reservoir is, as already stated, 5,578 acre-feet, obtained by a dam 45 feet high above low water, while the capacity of the proposed No. 3 reservoir, with a dam 75 feet high and 2,082 feet long, is only 65,535 acre-feet.

The surveys of the irrigable lands under the project now in progress are being made on a scale of 1,000 feet to 1 inch and with a contour interval of 5 feet, the methods used being the same as those used for the reservoir surveys.

CANAL SURVEYS.

The azimuth, as determined at the reservoir base-line station, was carried to the initial point of the canal surveys, i. e., the sill of the old head-gates at Avalon, and from this point an azimuth transit traverse was run down the canals, the distances between traverse stations being obtained by fore and back readings on double-targeted level rods, the reading being corrected for the focal length of telescope used. Azimuth observations were made at intervals and the computed azimuths were checked and, when in error, corrected. The latitudes and departures of the several traverse stations were computed and the points platted on the plane-table sheets. The platted positions of the points were checked by the method of tangents. The vertical control of the work consisted of a duplicate line of wye levels, center stakes being set each 100 feet along the canal and the surface elevation determined at each. Temporary bench marks were left at short intervals, and standard iron bench-mark posts were set at intervals of 2 miles. All level circuits were required to close within the standard limits of error.

A different procedure was adopted for the survey of the lateral system, the only instrument used being the transit, fitted with a good level beneath the telescope and a magnetic needle of good quality. The heads of all main laterals are shown on the plane-table sheets. The starting point for each lateral survey was the sill of the head-gates at the main canal, an elevation being obtained from the nearest bench mark. A needle line, distances being obtained by stadia and elevations carried by the use of the telescope level, was run down each lateral, and its position, direction, and grade thus determined. This survey is tied into the land corners so that the ditch can be platted in its proper location. Cross sections were also taken wherever needed. This gives data for determining the capacity of the ditch, also some information as to its probable cost and its present or future utility.

In addition to the surveys of the existing canal system surveys have also been made to determine the possibility of a relocation at Gyp Bend.

TEST PITS AND BORINGS.

A number of test pits have been dug on the site of the Avalon dam and spillway and on the lines at Gyp Bend, to determine the character of the material to be encountered in any projected work at these places. Borings with wash and diamond drill have been made at dam site No. 3 and at Avalon dam site, and satisfactory conditions have been found at Avalon.

Surveys were made at McMillan reservoir to determine the possibility and probable cost of shutting off the large leakage on the east side of the reservoir, of furnishing an adequate spillway capacity, and of raising the water level to the height which it was originally planned to raise it, viz, 25 feet on the gage, whose zero is the sill of the present head-gates. Test pits have been sunk here also where considered necessary.

UTILIZATION OF LAKE McMILLAN.

The further utility of Lake McMillan as a reservoir for the storage of large quantities of water depends entirely on the practicability of stopping the large leaks around the eastern shore. As matters stand at present the available storage capacity is found practically between gage heights 7 and 17 feet, though there is leakage at all heights. The available storage between gage heights 7 and 17 feet is, according to the values deduced by Mr. Reed, 15,900 acre-feet, the surface area of the lake being at the 17-foot stage about 3,150 acres. This amount is very small, and were it not for the probable large inflow to be expected would be of no value, since the evaporation would in the course of a year almost consume it.

Whether it will be well to make such betterments as will enable this reservoir to store 62,000 acre-feet of water is entirely a commercial question after the nature of the betterments and their probable cost have been ascertained. These betterments and repairs are as follows: (1) Stopping the leaks around the eastern side; (2) rebuilding the destroyed portions of the fill along the southern shore; (3) spillway repairs and reconstruction; (4) new head-gates. The problems presented in 2, 3, and 4 are simple of solution, but the most efficient and economical method of eliminating the leakage is problematical.

Two methods of doing this have been suggested. First, to fill in light straw, weeds, etc., at times when the water is flowing into the leaks and at the same time pump mud into them, so as to seal them if possible. Both the initial and final success of this method is uncertain. There is no assurance that the present leaks can be stopped in this way, nor is it certain that if the present ones are sealed others will not form elsewhere along the shore. Nor can any cost, even the most approximate, be assigned to this plan. It might be immediately successful or the efforts of several months might result in total failure to accomplish the desired results. Second, to build embankments that will cut off the water from all known deposits of gypsum. Surveys were made in June, 1905, to determine the position and volume of the embankments necessary to accomplish this result, but the flood in July opened so many new leaks that it would require an embankment about 5 miles long to cut them off from the reservoir, with no assurance that new leaks would not at once develop at or near the inner toe. This plan was therefore abandoned. Some use can doubtless be made of this reservoir, but commercially it is without value.

At the present time Lake McMillan spills at a gage height of about 16 feet, owing to the destruction by former floods of portions of the long embankment across the southwest end of the lake. In order to raise the level to 25 feet on the gage it will be necessary to rebuild the destroyed portions of this embankment and to provide an adequate spillway of capacity sufficient to pass 80,000 second-feet of water, which is the maximum flood so far experienced.

The necessary embankments will have a total length of 2,200 feet and contain a total of 39,781 cubic yards of earth. These banks will require riprapping on the water face, and this will take 5,057 square yards of riprap. The earth can be put in by scrapers with a haul of less than 100 feet, and the necessary riprap is already placed along the toe of the embankment.

No detailed plans have been made for the spillway, in view of the existing conditions, but sufficient work has been done to enable an approximate estimate of the cost to be made. The undeveloped plan contemplated a concrete overfall spillway about 800 feet long, founded on rock and with a discharge channel of sufficient area and grade to carry away the water, which was to be discharged into the same arroyo into which the lake now spills during flood stages. The lip of the spillway was to be at elevation 25 feet on the reservoir gage. To secure the necessary channel it will be necessary to excavate about 96,275 cubic yards of material.

RESERVOIR SITE No. 3.

Reservoir site No. 3 includes portions of secs. 9, 10, 11, 15, 16, 21, 22, 23, 26, 27, 28, 33, 34, and 35, T. 20 S., R. 26 E., of secs. 1, 2, and 12, T. 21 S., R. 26 E., and of secs. 6 and 7, T. 21 S., R. 26 E., and has a total area of 4,126.7 acres at the 2,355-foot contour, corresponding to a raise in water level of 65 feet. At this elevation it will have a storage capacity of 65,535 acre-feet.

It is proposed to build an earthen dam across the valley, to have a length on top of 2,082 feet, a crest width of 20 feet at an elevation of 10 feet above the maximum flow line, with a downstream slope of 2 to 1 and an upstream slope of 3 to 1, and with a maximum height of 76.2 feet above the present river bottom. Riprap will be placed on the upstream face.

Borings have been made at this dam site with wash and diamond drill and carried to a depth of 60 feet; they failed to develop the presence of bed rock, though rock stratified with clay was disclosed. The rock is not of sufficient thickness nor of sufficiently good quality to permit the construction of a masonry dam at this point.

There has been no opportunity to make a thorough investigation in regard to the occurrence of gypsum at this site. It will probably be found near the upper end, as the general trend of the exposures at Lake McMillan and to the south would carry this formation across the stream below the upper end of the reservoir.[a]

No points have been found at which the dip of the strata could be determined, and consequently it can not now be stated whether or not this reservoir site is feasible. In view of the conditions existing at the dam site, however, the scheme will have to be abandoned, unless it is practicable to raise the water level to the full height contemplated.

UTILIZATION OF LAKE AVALON.

Lake Avalon was the lower of the two reservoirs owned by the Pecos Irrigation Company, being located about 6 miles north of Carlsbad. It included portions of secs. 1, 2, 3, 4, 9, 10, 11, and 12, T. 21 S., R. 26 E., and a small portion of sec. 7, T. 21 S., R. 26 E. At the ordinary flow line it submerged an area of 934 acres and gave an available storage of 5,578 acre-feet. These figures differ very greatly from those published in various places, the submerged area being stated as 1,980 acres and the capacity as 6,300 acre-feet. The figures given here have been obtained from the contour map of the site, made during the progress of these investigations; they have been carefully checked and are believed to be accurate. As the lake has silted up to a considerable extent, and as the capacity given above is the available amount which could be drawn out through the gates, the original capacity was probably greater.

This reservoir was formed by a dam of similar type to that at Lake McMillan, though differing in dimensions and details. As constructed it was 1,380 feet long on the crest, with a maximum height of 50 feet. The downstream portion of the dam was formed of loose rock fill, with downstream slope of 1½ horizontal to 1 vertical, and a dry-laid wall on the upstream side with a slope of ½ horizontal to 1 vertical, the crown width being 10 feet. On the upstream side was an earth fill with a crest 10 feet wide and a water slope of 3½ horizontal to 1 vertical; this was covered with riprap apparently 12 inches thick. This was the second dam built on the same site and was destroyed by the flood of October, 1904, which broke the dam and cut a gap about 450 feet in width through the western portion. Since that time there has been no water in the reservoir.

The site has three spillways, aggregating about 780 feet in length. Spillway No. 1 is on the west bank of the river, about one-half mile above the dam. It has a length of 300 feet and spills at elevation 3,178.7, or 20.7 feet above the sill of the head-gates. Spillway No. 2 is located around the west end of the dam, has a length of 200 feet, and spills at elevation 3,178, or 20 feet above the sill of the head-gates. Both of these spillways are excavated into the soft shelly limestone and compacted clay and discharge into a small arroyo which leads the water into the river several hundred yards below the downstream toe of the dam. Spillway No. 3 is located in the intake canal just above the site of the head-gates; it is 190 feet long and spills at an elevation of 3,170 feet, or 12 feet above the sill of the head-gates. This spillway was closed by a row of 32 gates swinging outward, each gate being 4.7 feet wide and 7 feet high.

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[a] Recent investigations have shown the presence of beds of gypsum in this reservoir site.

These spillways were ample to carry the waters of the October flood, which reached, according to measurements made at Lake McMillan, a maximum of 80,000 second-feet. There seems to have been some leakage from this reservoir by percolation into the limestone hills surrounding it, and one point was found on the bottom having the appearance of a leak. So far as known, however, there is no gypsum beneath the site and it seems safe from such leaks as have destroyed the value of Lake McMillan as a storage reservoir.

Lake Avalon formed the distributing reservoir for the entire irrigation system and its loss will have to be made good before water can be again set running into the canals. This might be accomplished (1) by building a canal upstream from the mouth of the present canal to some point where a low diversion dam of the overfall type can be built, or (2) by a combined storage and diversion dam utilizing the serviceable portions of the old dam, with such changes and modifications in construction as may prove necessary or desirable. Surveys sufficient to permit comparison between these plans have been made.

A site for an overfall dam was located at a point about 2 miles above the present dam, but borings with diamond drill have not shown the presence of satisfactory bed rock. The necessary canal to carry the water from this point to the old canal was located, and the quantities of excavation have been computed, with the following result: Earth, 227,964 cubic yards; rock, 49,199 cubic yards.

It does not seem practicable to build a diversion dam at or near the site of the old Avalon dam, on account of the great cost of the necessary spillways. The excavation of a spillway of size sufficient to carry 80,000 second-feet would require the removal of about 172,000 cubic yards of material, a considerable portion of which would be classed as hardpan and require blasting to loosen, but could then be moved by scrapers. As a much smaller amount of material would rebuild the old dam and render available such storage as is to be had at Lake Avalon, the easiest and cheapest solution seems to be to rebuild the destroyed portion, strengthen the section if that is considered necessary, effectually cut off any underflow by a core wall beneath the dam to bed rock, and protect the downstream toe by a concrete wall to prevent any displacement by wash from the spillways.

HONDO PROJECT.[a]

A general description of the Hondo project and a statement of the operations up to the signing of the contracts for construction will be found in the Third Annual Report of the Reclamation Service.

The successful bidders were the Taylor-Moore Construction Company and the Slinkard Construction Company. Work was begun in a small way in December, 1904.

The Slinkard Construction Company, contractors for schedule No. 2, which was principally rock work, carried on operations with diligence, and completed their contract in July, 1905, within the time limit specified. The work was satisfactory to the Government, but was done at a loss to the construction company, owing to the fact that the contract price was too low for handling such material. The rock was unstratified, crystallized limestone interspersed with bodies of conglomerate, and required much more powder than the contractor had anticipated. It was also apparent that there were some mistakes in the methods of handling this material. The contractor, instead of using a face and working back, keeping a clear opening on one side, attempted to pulverize the material with powder and remove it with scrapers and teams. The methods were improved in the latter part of the work, and the cost to the contractor was less than at the beginning.

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[a] From report by W. M. Reed.

The Taylor-Moore Construction Company, who had been awarded schedules Nos. 1, 3, 4, 5, and 6, began work in January with only a small force, and being hampered by bad weather did not accomplish much until March. Even then their equipment was so small that they began falling behind with the work. They were notified to supply more equipment and force, and promised to do so, but their increase was not sufficient to accomplish the work within the specified time, and they were formally notified June 1 that they must satisfactorily show within fifteen days ability to complete the work; otherwise the Government would, under the terms of the contract, take possession of the equipment and carry on the work by force account. The same company had become involved on other Government work. The Comptroller of the Treasury had refused to pay money on estimates under a project the contractors for which were in default on any other Government work, and on June 7, being without any means of prosecuting this work, they turned it over to the Government, in accordance with the specifications of the contract. Since that date the work has been carried on by force account.

A board of engineers recommended that embankments Nos. 3 and 4 be readvertised and recontracted if the bids proved satisfactory. On this recommendation the Secretary advertised for bids for the completion of these embankments, to be opened October 17, 1905. But one bid was submitted—that of Wood, Bancroft & Doty, of Omaha, Nebr. The contract was awarded to them for $36,908.

The other work is being pushed toward completion. Some delay has been experienced on account of the nonarrival of iron that had been ordered by the Taylor-Moore Construction Company and the order confirmed by the Government for the purpose of saving time.

It is expected now that the work will be completed in time to conserve the 1906 spring floods, but owing to the fact that these floods usually come rather late, it is probable that water can not be delivered to the lands for the season of 1906. It is also expected that the distributing system will be constructed this winter, and will be prepared to deliver the water at the earliest possible date.

The expenditures on the Hondo project to September 30, 1905, were as follows:

Expenditures on the Hondo project to September 30, 1905.

Diversion dam and embankments:		
Excavation, Taylor-Moore Construction Company	$13,939.88	
Excavation (abandoned contract), force account	32,292.00	
Rock-excavation work, Slinkard Construction Company	26,087.04	
		$72,318.92
Telephone line, force account		3,606.00
Buildings, wells, etc		2,445.00
Purchase of lands		20,000.00
Preliminary examination, final surveys, engineering, inspection, and administration		8,256.96
Total		106,626.88

RIO GRANDE PROJECT.

The Rio Grande project—a proposition to build a concrete dam across the Rio Grande near Engle, N. Mex., about 100 miles above the city of El Paso, Tex., store the flood waters of the river, and construct a canal system irrigating 180,000 acres of rich valley land below—is fully described in the Third Annual Report, second edition, pages 395 to 426. A general map was published as Plate XLVII of the same volume.

WATER USERS' ASSOCIATIONS.

Since the publication of the Third Annual Report two water users' associations have been legally organized on the Rio Grande. They are the Elephant Butte Water Users' Association of New Mexico, with headquarters at Las Cruces, and the El Paso Valley Water

Users' Association of Texas, with headquarters at El Paso. They have obtained subscriptions from landowners for about three-fourths of the land necessary and are rapidly completing their work.

DIVERSION DAM AND CANALS.

During the spring and early summer of 1905 careful surveys were made for a permanent diversion dam near Leasburg, in Dona Ana County, N. Mex., and the main Mesilla Valley canal from that point to the Texas line. These surveys were begun by J. L. Rhead January 26 and were carried down the valley to a point near the Texas line by June 10, when they were stopped by high water in the valley due to a destructive flood. The object of this survey was to get a better diversion site than that first proposed at Peñasco Rock, and to get a better and cheaper line in the valley for the main Mesilla Valley canal than the high-level line that was at first located along the bluffs at the foot of the mesa, on the east side of the valley. A very satisfactory line was found in the valley, and Mr. Rhead has completed detailed contour maps in the Salt Lake office. He is still at work on plans for gate structures, arroyo crossings, canal drops, etc., all of which will be ready for inspection by a consulting board in a short time.

The construction of this diversion dam and about 3 miles of canal as a part of the general project would deliver water from the river into the present Mesilla Valley canals, which have no permanent heading. It is expected that such construction will be begun at an early date, as a first item, as soon as the water users' associations have submitted applications from the area of land necessary to secure the return of the cost for the entire Rio Grande reclamation project.

URTON LAKE PROJECT.

The Urton Lake project is fully described in the Third Annual Report. No work has been done during the present year except maintaining gaging stations on Pecos River at Santa Rosa and Fort Sumner. The information as to water supply that is being accumulated from gage readings and discharge measurements at these stations will be very useful whenever it becomes apparent that funds will be available for construction.

LAS VEGAS PROJECT.

The Third Annual Report gives detailed information concerning the proposed work at Las Vegas. So far no work has been done during the present year, except the hydrographic investigations under the direction of Mr. Hinderlider for determining the available supply.

During the latter part of October a soil survey was made of the irrigable lands.

LA PLATA VALLEY PROJECT.[a]

The La Plata Valley project is located along the north side of San Juan River, in San Juan County, N. Mex., the greater part of the land lying along La Plata River, a tributary of the San Juan.

The lands under the project are situated in T. 32 N., Rs. 12 and 13 W., Tps. 30 and 31 N., R. 13 W., and T. 30 N., Rs. 14 and 15 W. The nearest city is Durango, Colo., 35 miles to the northeast. The segregation of these lands under the first form of withdrawal was requested August 8, 1904. The total amount of land available for irrigation is 40,672 acres. Two plans have been proposed for the reclamation of the lands in the La Plata Valley: (1) A diversion from Animas River for the purpose of bringing water into the La Plata Valley, and (2) development of the storage reservoirs for the conservation of the entire run-off.

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[b] From report by M. C. Hinderlider.

ANIMAS RIVER DIVERSION.

Animas River rises in the San Miguel and Needle mountains in the southwestern part of Colorado. From its headwaters to a point about 15 miles above Durango it flows in a southerly direction through very rough and precipitous mountains, the bed of the river being at the bottom of a deep and narrow canyon. For this reason diversion from the Animas in this distance would be exceedingly costly if not impossible. About 15 miles above Durango the narrow canyon opens out into a broad valley which extends to Animas City, a distance of approximately 12 miles.

From Durango the Animas continues its southward course through a broken and rolling country to a point a few miles south of the State line, where it enters a narrow valley, through which it flows for a distance of 50 miles and finally joins the San Juan near Farmington, N. Mex.

When the preliminary reconnaissance was started it was thought that it might be possible to divert water from the Animas River at a point near Cedar Hill, N. Mex., which is near the State line, and carry it around the divide and into the La Plata drainage at a reasonable cost. Later surveys, however, showed that the line must tap Animas River in the vicinity of Durango in order to cross the divide by means of a comparatively short tunnel or cut. The head of the canal would be above the only available storage reservoir which is absolutely necessary to the project. If the canal heading were placed sufficiently low on Animas River to utilize the storage facilities it would be necessary to construct a long tunnel to convey the water into La Plata Valley.

At the beginning of the present field season the canal location was continued until the tunnel site between Animas and La Plata drainages was reached. A careful survey showed that the tunnel would be 16,000 feet long and would run largely through soft sandstone and hard clay. During the progress of this work the topography of the reservoir site on the Animas was developed on a scale of 1,000 feet to the inch with a 10-foot contour interval, and a dam site on a scale of 100 feet to the inch, with a 5-foot contour interval. After the tunnel line was located the canal line was run to La Plata River. Throughout the portion of the line from Animas River to the east portal of the main tunnel, numerous arroyos and drainage courses would have to be crossed, and syphons or flumes would have to be constructed. The difficulty of maintaining a large canal through this country is increased by reason of the large percentage of hillside construction necessary. The character of the region makes the line impracticable and the cost of construction is too great.

As an alternative it has been proposed to drop the greater portion of the water upon leaving the west portal of the tunnel directly into one of the numerous natural watercourses which finally enter the main arroyo of the McDermott Glade. At a point approximately 11 miles below the tunnel water may be diverted from this arroyo and a feasible line may be run to a distance of approximately 6 miles around the west side of the McDermott Glade to La Plata River, striking the latter 1 mile below the Colorado-New Mexico line. Such a line would be sufficiently low to avoid all rough and expensive construction, but the State-line reservoir could not be used. No survey or estimate of the cost to determine the feasibility of such a plan has been made, as the field work was terminated before this could be done. A very difficult feature connected with this undertaking would be the danger to the canal and the controlling headworks from the heavy intermittent floods that occur in the McDermott Glade.

The surveys show that any plan to irrigate lands in La Plata Valley by diverting water from the Animas drainage is impracticable.

RESERVOIR SITES.

A hasty preliminary survey was made of the reservoir site on La Plata River about 5 miles above the town of Hesperus, Colo. It was estimated that a dam 70 feet high and 1,800 feet long would impound 5,100 acre-feet of water. The great expense of this site rendered it impracticable.

Another reservoir site was surveyed on Cherry Creek, at Thompsons Park. It was found that a dam 150 feet high and 1,600 feet long would store 10,000 acre-feet; a dam 200 feet high and 1,800 feet long would store 22,200 acre-feet. The conditions at this location, however, are so unfavorable that the site was abandoned. About 4 miles northeast of La Plata, N. Mex., in sec. 3, T. 32 N., R. 13 W., is a reservoir site that was intended to impound water for the irrigation of lands owned by the Revenue Ranch and Water Company in Colorado and New Mexico. The capacity of this reservoir with a dam 50 feet in height and 650 feet in length is 1,095 acre-feet.

At the upper end of La Plata Valley is the State-line reservoir site, the largest on the river. At this place the mesa along the west side of the stream and the high sandstone cliffs on the east come close together and at the narrowest point there is a fairly good location for a dam. Practically the entire area in this valley, 700 acres, is now under cultivation and would have to be condemned if the site were used for the reservoir.

At the upper end of the Meadows, about 8 miles northwest of La Plata, is a reservoir site which is known as "The Narrows" reservoir site. A 50-foot dam would impound 12,000 acre-feet of water.

OPERATIONS IN NORTH DAKOTA.

By H. N. Savage.

WILLISTON DISTRICT PROJECTS.[a]

The projects comprising the Williston district are the Buford-Trenton project, the Williston project, the Nesson project, and the Cherry Creek project. (Pl. XLVII.)

Detailed descriptions of the land under each project will be found in the Third Annual Report, second edition, pages 439 to 442.

This tract is well supplied with transportation facilities, as the Great Northern Railway runs through the southern portion of the area covered by the Williston project and passes along the entire northern border of the Buford-Trenton area and within about 16 miles of the northern border of the Nesson area. The Missouri River will also furnish excellent means of transportation for all these projects.

OPERATIONS.

A general reconnaissance of the State was made last year by Mr. P. M. Churchill, under the direction of Mr. H. A. Storrs, for the purpose of ascertaining if suitable areas existed which could be readily irrigated by pumping, using Missouri River as the principal source of supply and the beds of lignite, which abound in this country, for fuel. After some preliminary work, attention was concentrated on the Buford-Trenton, Williston, and Nesson projects in the western portion, and the Bismarck project in the central portion of the State. Preliminary surveys and estimates having been made, the State was divided, Mr. James A. French taking charge of the Bismarck project and Mr. P. M. Churchill being assigned to the Williston district. A central office was established at Williston, in February, 1905, and field work on the projects constituting this district has been pushed continually since. In June Mr. H. N. Savage was appointed supervising engineer of these works. In the latter part of September a board of engineers, consisting of Messrs. A. P. Davis, H. N. Savage, O. H. Ensign, and H. A. Storrs inspected the projects and recommended that the work be pushed forward as rapidly as possible.

COAL INVESTIGATIONS.

The investigation of the coal in this district has been conducted by Mr. H. R. Evans; and included personal inspection of outcrops, the digging of test pits, and borings made by a steam drilling outfit and two hand wash-drilling outfits. Borings were made in the hills about 2 miles north of the railroad at Buford, and at points about 4 miles east, north, and west of Williston. These have been supplemented by test pits. At Nesson also test pits were sunk. The result of this work indicates that there are two main veins of coal—the upper one varying from 8 to 11 feet in thickness and the lower one averaging about 7 feet, which extend from Nesson to a point 2 or 3 miles west of Williston. Here these veins seem to be mixed with strata of clay and other material; farther west all the veins above the level of low water in Missouri River become more broken and at Trenton have divided into numerous thin veins, the thickest of which is 4 feet, diminishing toward Buford to 3½ feet. This vein also seems to pinch out on the south side of Missouri River toward the southwest. Lignite in workable veins does not, therefore, appear to exist on the Buford-Trenton project, but thick deposits of this coal have been found in the bluffs from 2 to 4 miles east of Williston and about 3 miles north of the proposed pumping site at Nesson. At Nesson a still lower vein of 6 feet has been found. The coal at Williston and Nesson is of exceedingly fine quality and lies at an elevation such that mines can be readily drifted in from the face of the bluffs and the coal carried by gravity to the power sites at both places. It is probable that power for the Buford-Trenton project will be generated at the Williston plant and electrically transmitted to the pumps at Buford.

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[a] From report by Percival M. Churchill.

In the fall of 1904 a carload of coal from one of these Williston veins was tested at the St. Louis Exposition. The results of this test may be found upon pages 20, 104–106, and 162 of Bulletin United States Geological Survey No. 261 (Preliminary report on operations of coal-testing plant at St. Louis). One carload of this coal was sent to St. Louis in August, 1905, for the purpose of making complete boiler and chemical tests and determining its efficiency. About 40 tons were also sent to Denver, Colo., at the same time, and will be tested in certain commercial plants that are now fitted especially for burning lignite coal. It is expected that the result will show very high efficiency. Ample supplies exist within a short distance of Missouri River, on Government land, at both Williston and Nesson. This land has been withdrawn from all forms of entry, and enough of it will be retained by the Government to insure one or two hundred years' supply.

WATER SUPPLY.

The water supply for irrigating the lands under these projects will be taken from Missouri River by means of centrifugal pumps lifting to elevations varying from 25 feet to 140 feet, although the larger part of the land will be covered with lifts varying from 25 to 85 feet. The minimum discharge of the Missouri, based on measurements in 1905, is about 7,000 second-feet, and the maximum discharge is about 70,000 second-feet. The water is of very good quality, and can probably be used for the boiler supply at power plants with very little treatment except the removal of silt. No difficulty is anticipated from the application of this water to the irrigable lands, as the silt is probably not sufficient in amount to be of very great importance. The few measurements taken this year indicate that ordinarily about 0.6 per cent (by volume) is carried, and that the maximum amount which may be expected is from 1 to 1½ per cent, this lasting only a few days at a time after severe storms.

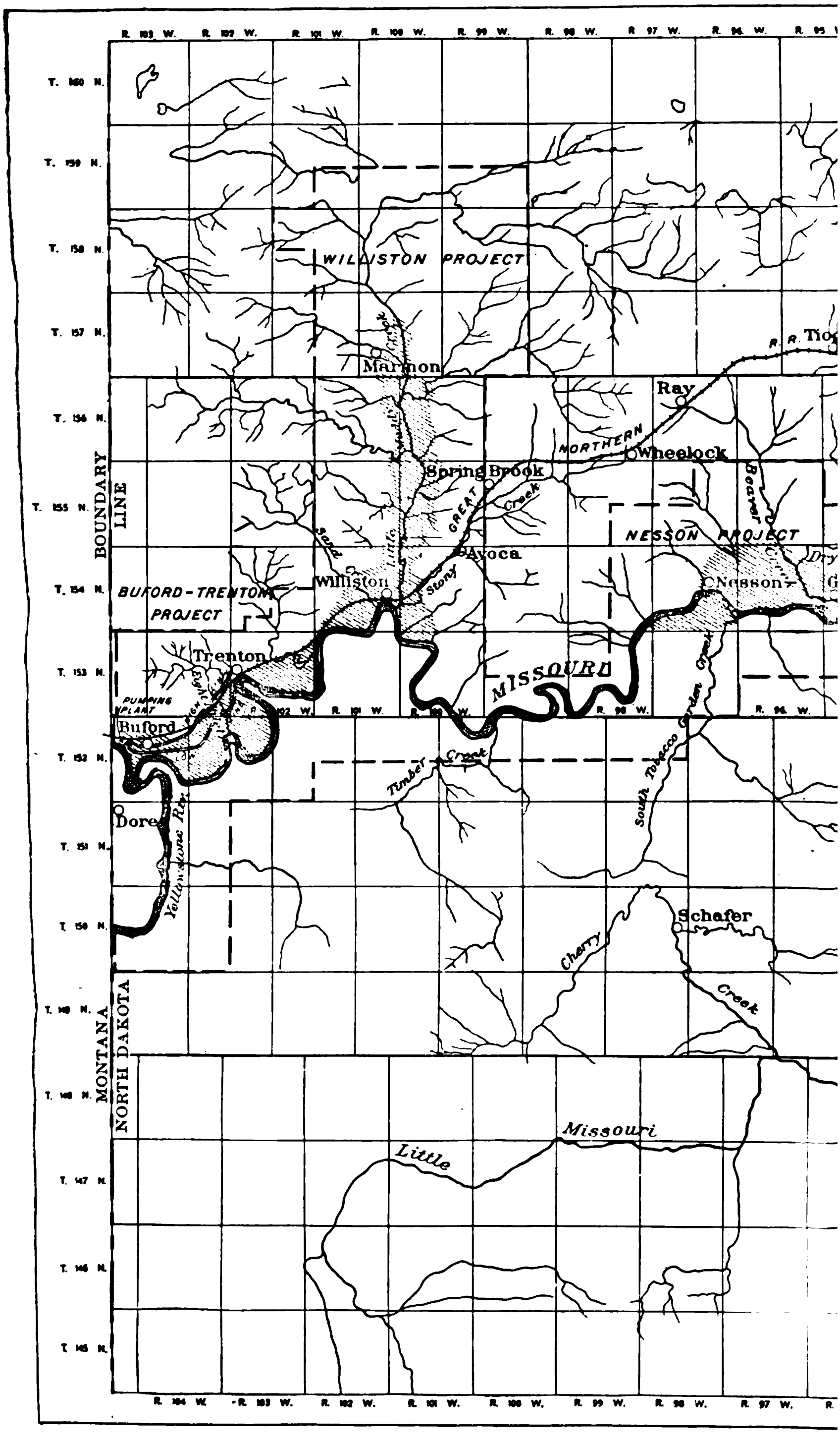
IRRIGABLE LANDS.

These lands are largely bench lands, and the soil ranges from a sandy gumbo on the lower benches to a sandy loam on the upper benches. Very little alkali seems to be present, and that only in a few spots. In all the projects the land lies exceedingly well for natural drainage. On the low benches near the river there is considerable brush and some timber, and it may be advisable to exclude some of this land from the projects. On the upper benches, and up Little Muddy Creek Valley, the land has no timber or brush, and except where it is being farmed is heavily grassed over, so that no clearing will be necessary, and the farmers could probably pay their first assessment by simply flooding the native grass already on the land and selling the hay.

Until within the last three or four years this part of the country has been considered fit only for grazing, and there were very few settlers. It is now occupied to such an extent that only an exceedingly small percentage of Government land remains, though few settlers have proved up on their claims. As most of them came from the more humid parts of the country they did not at first see the advantage of irrigation. As soon, however, as they investigated the projects presented to them they decided that they wished Government work to proceed. The details of their action will be presented under the heading of each project.

The average yearly rainfall in this district varies from 13 to 16 inches, and though a few farmers have been able to succeed fairly well with this rainfall, by using dry-farming methods, most of the crops are failures from lack of moisture.

U. S. GEOLOGICAL SURVEY



MAP OF PROPOSED BUFORD-TRENTON, WILLISTON, A

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BUFORD-TRENTON PROJECT.

GENERAL DESCRIPTION.

The area covered by the Buford-Trenton project has been described in the Second Annual Report, page 406, and in the Third Annual Report, page 427. It comprises about 27,000 acres, extending eastward from the Montana-North Dakota State line about 14 miles, and northward from Missouri River from 2 to 4 miles. It is usually divided into the Buford flat, which includes the first 9 miles from the State line, and covers about 22,000 acres, and the Trenton flat, lying east of this, and covering about 5,000 acres. Each of these flats has a low bench, which will be reached by a 25-foot lift, and a higher bench to the north. The Great Northern Railway runs along the northern part of both flats, and several small creeks run on to them from the hills above.

OPERATIONS.

In September, 1904, a reconnaissance was made and sufficient instrument work performed to determine approximately the area and elevation of this country, and a preliminary estimate was made during the following winter. Topographic surveys were commenced in February, 1905, on a scale of 1,000 feet to the inch, with 5-foot contours, and the survey for the entire Buford project was completed about the middle of July. The run-off of the creeks discharging on to this flat, and also of Missouri River, was measured, and various other data collected. Detailed topographic surveys were made on a scale of 100 feet to the inch, with 2-foot contours, covering the probable location of the pumping-plant intake and pressure pipes and certain portions along the low-line canal.

OUTLINE OF PROJECT.

The water supply will be pumped from Missouri River at a point about a mile east of the Montana-North Dakota State line and delivered into three canals at approximately the 25, 70, and 110 foot lifts. It is probable that the Trenton flat will have a separate pumping plant, located somewhere near the southernmost point of the flat, to lift the water about 20 feet to the ridge which runs through this part of the project. Power for these two stations will probably be furnished from the Williston power plant. The areas under each lift are shown by the accompanying table.

WATER USERS' ASSOCIATION.

On February 26, 1905, a preliminary organization was formed at Buford. The organization was incorporated April 17, and has since then subscribed the larger part of the irrigable land under this project. The table shows the percentage of the total project subscribed and the percentage of Government land under each ditch. The board of engineers recommended the setting aside of part of the money to build this project November 2, 1904, and of an additional amount sufficient to complete it September 25, 1905.

WILLISTON PROJECT.

GENERAL DESCRIPTION.

The Williston project heads at Williston, on the north side of the Missouri, and covers the river benches, which extend 4 or 5 miles to the east and west, and about 20 miles of Little Muddy Creek Valley, which extends due north from Williston and is approximately 3 miles wide. The project embraces about 40,000 acres, but is capable of extension to flats on the other side of the river, making a total of approximately 70,000 acres.

OPERATIONS.

Topographic surveys were commenced in February, 1905, and finished about the middle of October. About 40,000 acres were plotted on a 1,000-foot scale, with 5-foot contours, and five possible sites of pumping plants on a 100-foot scale, with 2-foot contours; the run-off of the various creeks in the vicinity and of Missouri River was studied and silt measurements and various other data were obtained.

OUTLINE OF PROJECT.

It is proposed to pump the entire supply from some point on the banks of the Missouri, and to deliver the water into three canals, with lifts ranging between 35 and 120 feet, pumping into a low-line canal running about 4 miles north of Williston, lifting here to the high-line canal on the west side of Little Muddy Creek, and then crossing the creek and lifting to two high-line canals on the east side. All these pumping plants will be supplied with power from one central plant, which will be located with reference to the coal and water supplies.

WATER USERS' ASSOCIATION.

A water users' association was incorporated at Williston May 22. This association was requested to obtain signers to an informal petition requesting the Secretary of the Interior to carry investigations on this project to a point where an estimate of cost could be made. The board of engineers which was convened here in September recommended setting aside money for the construction of this project and the people have been requested to complete their organization and obtain signatures preparatory to executing the necessary contract with the Secretary of the Interior, in order to enable construction to commence next spring.

NESSON PROJECT.

GENERAL DESCRIPTION.

The area covered by the Nesson project consists of bench land situated about 30 miles east of Williston, the larger part being on the north side of Missouri River. This major part is in two benches, both of which are fairly smooth and have good drainage toward the river. A few creeks run onto or through this territory. The lower bench covers about 6,500 acres and the upper bench about 14,000; the bench on the south side of the river covers about 4,000 acres. On the lower benches, on both sides, there is some brush and timber land which may possibly be excluded from the project. The rest is fine grass land, except where cultivated.

OPERATIONS.

A reconnaissance and preliminary survey was made in October, 1904, and a preliminary estimate of cost worked up during the winter. In March, 1905, topographic surveys were commenced. About 25,000 acres have been mapped on the scale of 1,000 feet to the inch, with 5-foot contours. The creeks have been gaged and many other data obtained.

OUTLINE OF PROJECT.

As in the other projects, it was contemplated to use the run-off of the various creeks adjacent to the land, but that idea has been abandoned, owing to the small amount of water which can be obtained from this source, and the supply will be pumped from Missouri River. The main pumping and power plant will be located on the western edge of the area and water delivered from here to the low-line canal, and probably to the two high-line canals. About 5 miles east of this point another pumping plant will be erected to lift water to two intermediate canals. The proposed lifts are approximately 30, 60, 80, 105, and 137 feet. Coal for this project is found in 8 to 11 foot veins, on Government land about 3 miles northwest of the power plant. For the land south of the river a pumping plant will be erected and power electrically transmitted to it from the main plant. The lift here will be 34 feet.

WATER USERS' ASSOCIATION.

Several meetings were held by the water users under this project during the spring and early summer of 1905. A temporary organization has been formed, but is not yet incorporated. The board of engineers which convened in September, 1905, recommended setting aside the money necessary for the construction of this project, and the water users' association will now be organized.

CHERRY CREEK PROJECT.

A reconnaissance was made in October, 1905, by Mr. A. L. Fellows, State engineer, who reported that there was an ample supply of good irrigable land, but no sources of water supply, except Missouri and Little Missouri rivers, the latter being very uncertain and unsatisfactory, and that the lift from each would be about 200 feet.

Statistics of Williston district projects.

Area.	Canals.				Lands.			Elevation at pumps, 1905.		Minimum discharge of Missouri River.
	Name.	Elevation at bottom.	Lift.	Length.	Area covered.	Subscribed.	Owned by Government.	Low water.	High water.	
		Feet.	*Feet.*	*Miles.*	*Acres.*	*Per ct.*	*Per ct.*	*Feet.*	*Feet.*	*Sec.-ft.*
Buford	Low line	1,888	25	10.5	13,000	62.3	18.5	......	......	....
	Middle line	1,930	67	14.2	6,700	83.5	6.0	......	......	....
	High line	1,975	112	17.0	2,100	81.0	9.5	......	......	....
		......	......	....	[a]21,800	70.4	13.7	1,863	1,872	[b]8,000
Trenton	Low line	1,865	20	4.5	5,240	65.0	14.8	1,845	1,854	10,000
Williston	Main low	1,865	30	8.0	1,600	....	3.8	......	......	....
	West high	1,950	175	45.0	16,800	....	14.9	......	......	....
	East middle	1,908	73	13.0	6,000	....	8.7	......	......	....
	East high	1,955	120	21.0	5,500	....	27.0	......	......	....
	West low	1,865	30	6.0	3,800	....	2.1	......	......	....
	East low	1,865	30	6.0	4,900	....	10.0	......	......	....
		......	......	....	38,600	....	13.3	1,835	1,844	10,000
Nesson:										
North side	Low line	1,825	±27	15.5	6,500	....	3.1	......	......	....
	62-foot lift	1,860	62	10.75	3,000	....	23.0	......	......	....
	82-foot lift	1,880	82	9.5	3,300	....	27.0	......	......	....
	105-foot lift	1,907	105	17.3	5,500	....	3.6	......	......	....
	High line	1,939	137	6.5	2,100	....	0.0	......	......	....
		......	......	....	20,400	....	9.8	1,798	1,807	10,000
South side	South	1,834	34	8.0	4,100	....	40.0	......	......	....

[a] Of this, Indian allotments cover 720 acres (3.3 per cent).
[b] Above Yellowstone.

BISMARCK PROJECT.[a]

The district to be irrigated under the Bismarck project (Pl. XLVIII) is in T. 138 N., R. 80 W., near Bismarck. The Northern Pacific Railway bridge crosses Missouri River 2¼ miles west of the city. Here an extensive amount of work has been done in the past twenty years by the United States engineers and the railway company in building jetties and riprapping along the river banks to confine the river channel to one locality Below the bridge for several miles the current of the river is toward the east bank. The riprapping extends along this bank from the bridge to a point a thousand feet downstream, below the site selected by the Reclamation Service for the pumping station. The protection of the river banks makes this location an ideal one for a pumping plant; moreover, it is close to the tract that will be irrigated.

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[a] From report by James A. French.

The hills recede immediately east from this site, leaving a level bench of bottom land which contains approximately 7,000 acres, about half of it adjacent to the river being heavily timbered. This timbered area protects the open meadow from erosion by the river floods. Its general elevation is approximately 25 feet above extreme low water in the river. Adjoining this is a second bench, known as the Fort Lincoln or Post bench, which contains approximately 3,500 acres and lies at an elevation 25 feet higher. To the north and west, 25 feet higher still, is a third bench, known as the Penitentiary bench, containing approximately 3,500 acres. The second and third benches drain eastward into Apple Creek, which in turn passes south of the second bench and through the lower end of the first bench into Missouri River.

The lower bench, with the exception of a small area in wheat, is given over entirely to the native hay crop. This bench is flooded every few years, owing to ice gorges in the river during the spring break up. It is not inhabited, presumably on account of the loss to property that would result from these floods. One flood is sufficient to produce a good hay crop for the following two years. The soil is heavy and underlain by sand and gravel; in a few places along the upper edges of the bottom, where cultivated, it is very productive.

The second and third benches are typical of the North Dakota prairie, both as to soil and formation. They are free from the glacial bowlders so common in this part of the country. The top soil is a heavy loam and very productive whenever the rainfall is sufficient. Probably one-half of this area is under cultivation—mostly in wheat. The distribution of water over these benches, while difficult, owing to their rolling nature and isolated knolls, should not be expensive.

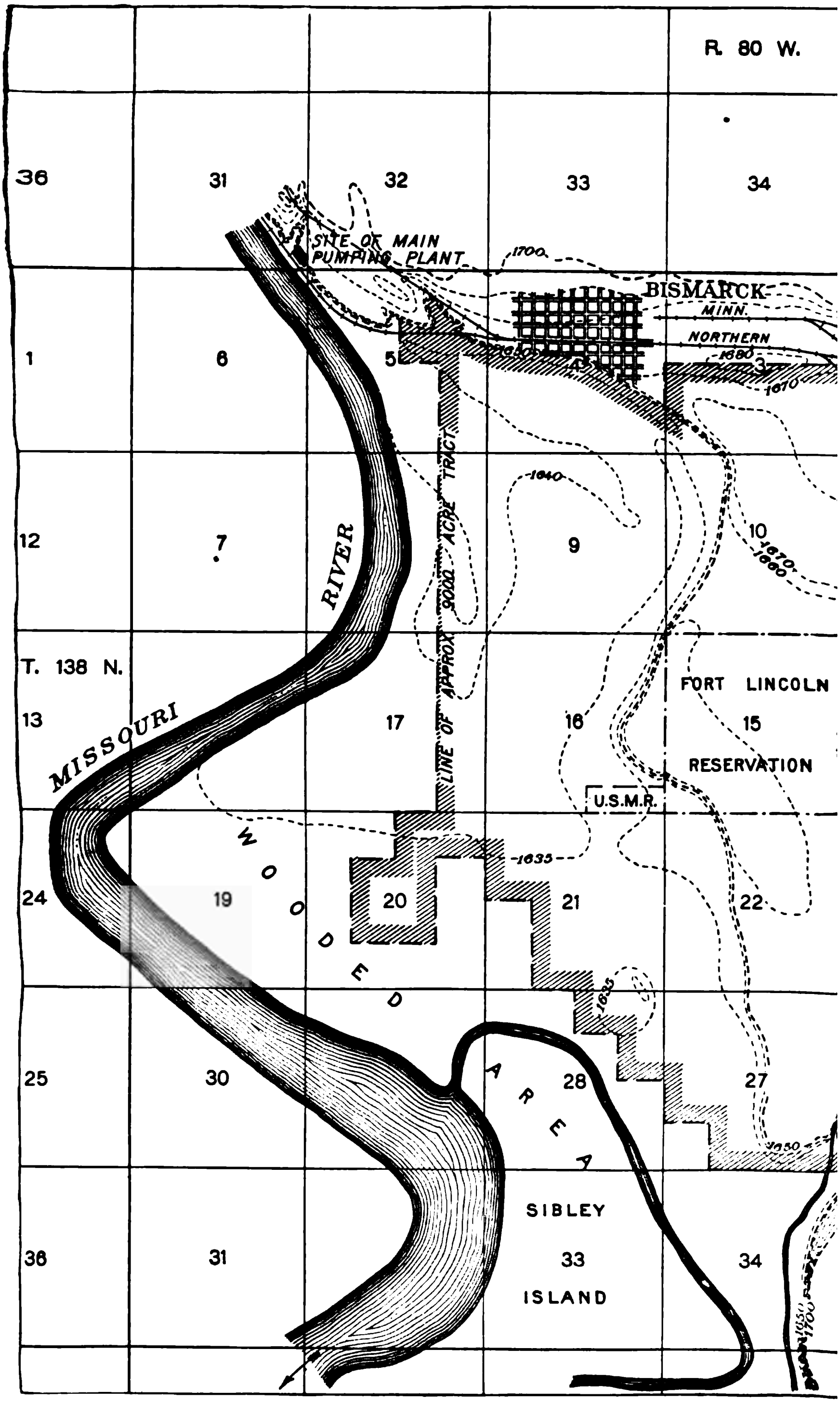
Surveys were begun in August, 1904. A line of levels was carried to the east, toward McKenzie, on the Northern Pacific Railway, and through McKenzie Slough to Long Lake, with the object of studying the possibility of using Long Lake as a distributing reservoir for lands lying south and east of Dawson and Steele.

After the close of the field season a board of engineers, consisting of Messrs. Fitch, Storrs, and Churchill and the chief engineer examined the plans and recommended that the project be undertaken. On November 18, 1904, the Secretary of the Interior set aside tentatively the sum of $250,000 for this project.

Land was withdrawn from entry under the first form of withdrawal by the Secretary on January 20, 1905, approximating 1,543,680 acres, all of which except about 90,000 acres has since been returned to entry, the larger part of this latter area being in private ownership. These lands were withdrawn at a time when information as to the probable extent of the project was lacking, and also for the purpose of making investigations during the next field season of the location and extent of lignite deposits which might furnish the fuel supply for the pumping plants.

In May, 1905 the reconnaissance of the Little Heart and Fort Lincoln areas was taken up, and a plane-table survey made on a scale of 2,000 feet to the inch, with 10-foot contours. Approximately 50 square miles were covered in this vicinity during May and June. The results showed that about 25,000 acres of land in the Little Heart district laid well for the distribution of water under a 200-foot lift from low water in Missouri River. The Missouri after leaving the Bismarck flats flows westerly and against the hills at Fort Lincoln (now abandoned), where there is a fair location for a pumping station. A lift of 80 feet from low water here will cover 5,000 acres of land, one-half of which is timbered bottoms, the remainder corresponding to the second bench near Bismarck.

U. S. GEOLOGICAL SURVEY



MAP OF PROPOSED BISMARCK PROJE

While these surveys were being carried on in the vicinity of Fort Lincoln, detached parties were at convenient times working on Apple Creek to determine the possibility of using it as a reservoir to relieve the pumping plant at Bismarck. From a study of these surveys it appears that it is impracticable to use the waters of Apple Creek in conjunction with the pumping project. Gaging stations were maintained on the creek and the spring run-off and rainfall were observed and measured. There was practically no run-off from the melting snows this season, though they generally send down the creek a large amount of water. During May and June there was considerable rainfall, but it had little effect on the discharge of the creek. The total discharge from February 28, to July 30, was approximately 7,300 acre-feet.

A detailed survey of the Bismarck project was begun July 1, on a scale of 400 feet to 1 inch, with 5-foot contours. Twenty square miles of topography was completed by August 15, covering the lower, middle, and upper benches of the Bismarck project. The accompanying map (Pl. XLVIII) shows the probable limits of the area available—something less than 9,000 acres. A map of the pumping site on a 50-foot scale, with 2-foot contours, was also made during this period.

MOUSE RIVER PROJECT.

A reconnaissance on Mouse River has shown a large area of irrigable lands. To get water on these lands will require a dam across the river and a canal large enough to divert the flood water. The fall of the river is very small—about 1 foot to the mile—and without a dam the lands can not be reached. Mouse River rises in Canada and returns to that country after flowing about 180 miles through North Dakota. The flow is very small except at times of flood during April and May. The average annual run-off is about 240,000 acre-feet. A rough estimate has been made on the basis of an earth dam about 45 feet high and 3,000 feet long, with a masonry core wall. A flood-water canal 32 miles long, carrying 1,850 second-feet, would bring the water to a point where storage could be had. The irrigable lands have not been surveyed, but it is thought there may be 100,000 acres.

OPERATIONS IN OKLAHOMA.

By B. M. HALL.

SOUTHWESTERN SECTION.[a]

A very complete reconnaissance has been made of the streams in Custer, Roger Mills, Washita, Greer, Kiowa, and Comanche counties. The reservoir sites formerly surveyed on North Fork of Red River at Lugert and on Otter Creek near Mountain Park (described in the Second and Third Annual Reports) were examined and preliminary canal surveys were run from them to determine the feasibility of using each as a separate system instead of combining them into one system as was formerly suggested.

NAVAJO RESERVOIR SITE.

SURVEYS.

In the course of the above surveys a reservoir site was found which commands a larger water supply and affords more storage than any other site discovered. This is known as the Navajo reservoir site, and is on North Fork of Red River in Greer and Kiowa counties, opposite Navajo Mountain, 10 miles west of Mountain Park and 4 miles north of Headrick. Preliminary surveys were made to determine approximately the dimensions of the dam and capacity of the reservoir. The results being satisfactory, accurate plane-table surveys were made of the dam site and reservoir site, also surveys for locating canals and laterals and estimating their cost.

This site would have the natural drainage from 5,470 square miles in Oklahoma and Texas. Surveys from Salt Fork of Red River show that it can be diverted at a point 2 miles above Mangum and brought into the Navajo reservoir with 15 miles of canal. Such a flood-water canal would be expensive, but it would give an additional drainage area of 1,224 square miles. Investigations near Elk City showed that it was impracticable to divert upper Washita River into the Navajo drainage basin. A plane-table survey of this reservoir was made on a scale of 2,000 feet to the inch, with 5-foot contours, and from this the capacity of the reservoir was computed. The elevation of the river at the dam site is 1,345 feet. There is a wide gap in the divide 6 miles northwest of the dam site, in secs. 15 and 22, T. 3 N., R. 19 W., at an elevation of 1,408 feet. In order to bring the storage level of the reservoir to the 1,405-foot contour, or 60 feet above the river at the dam site, an embankment 7,500 feet long and 9 feet in maximum height will have to be built; if the storage level is raised to 65 feet above the river at the dam site, or up to contour 1,410, the length of this embankment will be 9,500 feet and its maximum height 14 feet.

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[a] From report by James G. Camp.

Capacity of Navajo reservoir, on North Fork of Red River.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
1,350	100	250	250
1,355	289	970	1,220
1,360	771	2,650	3,870
1,365	1,560	5,830	9,700
1,370	2,245	9,515	19,215
1,375	2,990	13,000	32,305
1,380	3,937	17,320	49,625
1,385	4,838	21,940	71,565
1,390	5,998	27,090	98,655
1,395	7,151	32,870	131,525
1,400	8,517	39,170	170,695
1,405	10,447	47,410	218,105
1,410	12,093	56,350	274,455
1,415	13,660	64,380	338,835

DAM.

The Navajo dam site is at a point known locally as Little Coulter Mountain. From the north a granite ridge projects to the water's edge; on the south side at the edge of the stream is a granite butte 110 feet higher than the river bed. It is 460 feet across the river from rock to rock. Back of the butte is a gap where the sandy soil of the hillside meets the rock. This would need an embankment 34 feet high in the highest point, and 1,500 feet long on top. The latest diamond-drill borings indicate that granite bed rock in the river is at a greater depth than had been expected. A masonry dam, extending from the butte on the south to the ridge on the north and along its crest, would be 460 feet long at river bed, 75 feet high above river bed, and 2,200 feet long on top. The ridge, being solid granite, would make an excellent spillway. Of the 2,200 feet of length, 1,200 feet would be the masonry dam, and 1,000 feet along the ridge would be a spillway at 60 feet above the river bed and 15 feet below the crest of the dam.

A broad, low gap at the 1,408-foot contour on the west side limits the height of water level. An embankment 7,500 feet long will be necessary to bring this gap to elevation 1,417, the level of the dam crest. An additional 5 feet would increase the length to 9,500 feet.

DIVERSION DITCHES.

As there is fine land on both sides of the river below the Navajo reservoir at about equal distances, a ditch line was run on both sides. The Greer County ditch follows along the river bank 1 mile and then cuts through the sand hills a distance of 1¼ miles, across the horseshoe bend. These sand hills are a choppy mixture of ridges, draws, and basins, but a comparatively cheap line was found through. Water standing in the basins proves that the material will hold water. Probably 3 to 1 slopes on banks will be necessary in this portion to prevent sandy banks sliding. From this point the line follows the river bottom on easy slopes to east of Headrick. A line on grade follows a very irregular course around the end of the divide, having 3,000 feet of steep hillside and 1,540 feet of rock. To avoid this, four cut-off lines were run across the point, and the northernmost one, passing above the town with a cut 20.5 feet deep in the center and 5,900 feet long, was thought the best route. This cuts off 4.9 miles in the distance and avoids all rock and steep hillsides, also a difficult railroad crossing. From the outlet of the cut a small lateral running south would supply the land at the end of the ridge. The main route from here encounters no difficulties, passing across the Stinking Creek Valley above 90,000 acres of farming land. It was continued along the east slope of the Altus divide to a point 7 miles below Altus, where it crossed the divide, but a sufficiency of land will be found without going so far. This line was 35.5 miles long.

The Kiowa-Comanche ditch line follows the river bank for a mile, then close to it on a clay bank for 4 miles more. From this point it runs on a sandy hillside until at the end of 9.5 miles it passes by a small cut through the point of the ridge which bounds Otter Creek Valley on the north and west. From this point the line is on easy slopes along the foot of this ridge to above Snyder, where it crosses Otter Creek; thence it follows down the east side of the valley on easy slopes to the Comanche County line, covering 40,000 acres of fine land, and from this point it takes a southeasterly course, covering a fine tract of 80,000 acres in Comanche County.

Quantities for Navajo diversion ditches.

Greer County ditch, 35.5 miles long, 959,340 cubic yards:
    Headrick cut, 109,700 cubic yards.
    Main laterals, 12,672 cubic yards.
    Minor laterals, 360,000 cubic yards.
    Bridges—
        9, 45-foot span.
        25, 30-foot span.
        41, 15-foot span.
    Railroad crossings—
        2, 50-foot span.
        2, 30-foot span.
    Flumes—
        2, 50-foot span 30 feet wide.
        3, 20-foot-span 12 feet wide.
    Rock culverts—
        2, 8 by 10 by 40 feet.
        13, 6 by 8 by 40 feet.
    Cement headgates, 420, average capacity 3 second-feet.
Kiowa-Comanche ditch, 54 miles long, 1,207,734 cubic yards:
    Main laterals, 264,000 cubic yards.
    Minor laterals, 350,000 cubic yards.
    Bridges—
        11, 45-foot span.
        12, 30-foot span.
        29, 25-foot span.
        42, 15-foot span.
    Railroad crossings—
        1, 45-foot span.
        2, 30-foot span.
    Rock culverts—
        6, 6 by 8 by 50 feet.
        4, 6 by 6 by 40 feet.
        13, 4 by 6 by 30 feet.
    Cement headgates, 430, average capacity 3 second feet.

These canal estimates were made from the preliminary surveys. Since that time careful locating surveys have been made, but the estimates from them are not yet completed.

The duty of water will vary greatly, as the rainfall fluctuates, not so much from year to year as in regard to the time of the year it occurs. In one year it may come mainly in the early and late parts of the season, while in another it may be distributed through the season.

Concerning the water supply the data at hand are very incomplete, the measurements of 1903 and 1904 being on but three tributaries—North Fork above the Lugert reservoir, Elk Creek above the Navajo reservoir, and Otter Creek near the dam site. A comparison of estimates from the flow at these points in 1904 (the dry year) would indicate that 60,000 acres may be irrigated from the Navajo reservoir. The stream measurements, under charge of Mr. Giles for 1905, show a flow of 287,800 acre-feet from April 14 to September 30.

SUMMARY.

Plans and estimates are being completed as rapidly as possible for submission to a consulting board. They have been delayed mainly on account of the diamond-drill borings for bed rock in the river at the dam site. These borings are very disappointing, as they are showing bed rock at a much greater depth than was expected, which adds very largely to the uncertainty of the project. The abutments are of solid red granite, 460 feet apart at the river level, and there was every indication of shallow bed rock in the river. If these expectations had been realized, no great diffculties would have been presented in dam construction.

The hydrographic work on the drainage basin tributary to this reservoir indicates that the water supply will be ample for the irrigation of 60,000 acres, and if the difficulties that have presented themselves can be met at a reasonable cost the Navajo project will be a very desirable one. There are over 200,000 acres of rich land lying immediately below the dam site. The available water supply will therefore set the limit to the enterprise.

LUGERT RESERVOIR SITE.

The site of the Lugert reservoir is on North Fork of Red River, near the town of Lugert. The gaging for 1904 gave a total discharge of 68,500 acre-feet. With a dam 70 feet high the following capacities are obtained:

Capacity of Lugert reservoir.

Contour.	Area.	Capacity of section.	Total capacity
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
1,500	204	510	510
1,510	754	4,788	5,298
5,120	1,735	12,440	17,738
1,530	2,445	20,901	38,639
1,540	3,175	28,104	66,743
5,146	3,853	21,065	87,828

The dam site is between two granite points, at the bottom 478 feet apart. At a height of 78 feet the length of dam on top would be 692 feet. This would give a surface water line at the 1,546-foot coutour. To raise the water level any higher would necessitate building a long embankment on the east side. Until tests have been made in the river bed to demonstrates how deep it will be necessary to go for solid-rock foundation, no definite estimate of cost can be made.

Diversion from the Lugert reservoir into Kiowa County is impracticable, owing to the heavy construction that would be necessary around granite mountains on the east side of the river. On the Greer County side a very feasible route was found. A mile below the reservoir a rock point will necessitate 400 feet of flume. This is the only rock on the line. A mile of 4 to 1 slope hillside is encountered a mile farther on, but this is a good firm clay. Beyond this, the line is on almost level country in sandy loam soil. A good crossing was found for a flume over Elm Fork 460 feet long. After crossing Elm Valley there was choice of two routes—to follow around the canyon side on steep slopes to the Navajo gap, or to cut through a low gap north of Blair. The latter was surveyed first and proved so feasible that the other was not surveyed. A cut 5,500 feet long, 30 feet deep in the center, would carry the water to the upper edge of 80,000 acres of fine land, the ditch being 7.7 miles long from the reservoir. This cut takes the place of 22 miles of ditch around the mountain. At its lower end the ditch forks. The west branch, 9 miles long, runs a little south of west to Salt Fork. From this laterals can be run south, often on section lines. The east branch, 25 miles long, runs southeasterly, skirting the sand hills, with an occasional drop to keep below them, passing across the head of Stinking Creek and around the south end of Navajo Mountain. From this line the country has an even southward slope of about 25 feet to the mile, making distribution very easy. At a point 6 miles from the cut on this line the Altus divide branches off nearly south. A lateral following the crest of this divide, except where two buttes are above grade, would distribute water east to Stinking Creek and west to Bitter Creek.

Below these lines and above the Navajo lines lies twice the amount of land which the Lugert reservoir can supply. The work on these lines would be approximately as follows:

Quantities for Lugert diversion ditch.

Main line to cut, embankment, 313,780 cubic yards.
Cement flume, 400 feet, 340 cubic yards.
Steel flume, 450 feet.
Elm cut, 173,300 cubic yards.
West branch, 184,150 cubic yards.
East branch, 220,500 cubic yards.
Altus and Martha divide ditches, 193,000 cubic yards.
Minor laterals, 216,000 cubic yards.

MOUNTAIN PARK RESERVOIR SITE.

This site is about 2 miles north of Snyder, on the main Otter Creek. The drainage area is 126 square miles. The gaging showed a flow of 5,358 acre-feet in 1903 and 4,354 acre-feet in 1904.

The dam site is in a granite canyon 40 feet wide at bottom and 243 feet wide at height of 50 feet. Mr. Bonstead estimated that a rock-fill dam would cost $102,500, in addition to the condemning of 4,000 acres of land at $20, or $80,000.

Capacity of Mountain Park reservoir.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-ft.*	*Acre-ft.*
1,370	17	42	42
1,375	163	450	492
1,380	548	1,785	2,277
1,385	1,265	4,612	6,889
1,390	2,154	8,541	15,430
1,395	3,014	12,921	28,351
1,400	4,327	18,354	46,705

As the supply is so inadequate, investigations were made concerning the feasibility of diverting other streams into this basin. By a large expense Elk Creek could be so diverted, but as it flows naturally into the Navajo basin that line was not surveyed. To the east of the Mountain Park basin is Horse Branch, and 2 miles farther Dry Otter Creek. These streams drain about 100 square miles, and an approximate estimate would give them a flow of 6,000 acre-feet.

In Otter Creek Valley, above the line of the Navajo ditch and below the Mountain Park reservoir, is a tract of about 10,000 acres of first-class land. To cover this, two ditches are necessary. For a mile below the reservoir dam the stream runs in a canyon on the side of which ditch construction would be heavy, owing to the steep slope and rock. To avoid this, a diversion dam was planned 1 mile below the reservoir dam to raise the water 24 feet. From this dam water can be diverted on both sides on easy slopes. It would also back water 20 feet deep against the lower side of the reservoir dam, making a cushion for the overflow.

On the east side the line would be in bowlders for one-fourth of a mile, then on easy slopes up Horse Branch Valley, crossing at the railroad. It would be necessary to make a cut through a gap back of the mountain to avoid several miles of ditch, much of it in rock, around a granite butte. This cut would be 5,700 feet long and 27 feet deep in the center. It would be rather costly, unless the town of Mountain Park would bear a portion of the expense. It might be advisable to drop to a lower grade and go below the butte. The upper line would pass through town; the lower line below it. As there is more than sufficient land, there is no necessity for keeping on the high line. On either line the ditch would be on easy slopes below Mountain Park.

The west side diversion would follow the foothills to a point west of Mountain Park, where it could cross over and cover a narrow strip lying above the Kiowa ditch from the Navajo reservoir.

Several lines were run from a point 5 miles east of the Mountain Park reservoir, on Dry Otter Creek. The one thought best was 2.5 miles long to the top of the divide between that creek and Horse Branch, just above the forks. From that point the line would be 2.8 miles long to a gap at the east side of the Mountain Park reservoir. Gagings from April 19 to August 31, 1905, show a flow of 8,478 acre-feet in Dry Otter Creek and 7,788 acre-feet in Horse Branch. To divert the flood waters of these two streams into the proposed Mountain Park reservoir would require a ditch 150 feet wide, 10 feet deep, grade 0.2 to 1,000, from Dry Otter Creek, and one 100 feet wide and 10 feet deep from Horse Branch. The total flow given for Horse Branch occurred practically in six days. Estimates made on the Mountain Park site show that the cost is too great for a practical project.

RECONNAISSANCE IN BEAVER AND WOODWARD COUNTIES.[a]

Beaver and Woodward counties lie in a semihumid and arid region, the rainfall decreasing from 28 inches per year in the eastern part of Woodward County to 12 or 13 inches in the western part of Beaver County. Consequently, for profitable farming, irrigation would be a great benefit to Woodward County and is essential in Beaver County.

The soil may be divided into prairie land and bottom lands. The former includes red land derived from the decomposition of red sandstone and gypsum and light-chocolate alluvial deposit. The bottom lands are river alluvium, sandy soil, and sand hills, all but the sand hills being very rich and fertile.

DRAINAGE.

This region is traversed and drained by Cimarron and North Canadian rivers and their tributaries. The Cimarron rises in the Raton Range and the Sierra Grande near Folsom, N. Mex., and flows in an easterly direction to Garrett, Okla., through a volcanic and sandstone region, in which it has eroded a gorge 400 feet deep and from one-third to 1½ miles wide. In this gorge good building stone is plentiful. Below Garrett the nature of the stream and of the surrounding country changes. The stream becomes wide and sand choked and meanders through a wide, deep valley which it has eroded in red sandstone ("red beds") and gypsum and in which building material is very scarce. This valley is from 2 to 4 miles wide and from 350 to 450 feet below the level of the plains. The slope of the river decreases from 16 feet per mile near Kenton, Okla., to one-half that amount near Englewood, Kans. The steep slope and the rocky nature of the watershed above Garrett are conducive to great floods of short duration. At that place a rise of 10 or 12 feet in less than one hour, with a gradual return to normal stage in a few days, is not uncommon. Below Garrett these floods spread out, and consequently are less violent, but last longer.

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[a] From report by W. W. Schlecht.

The North Canadian, or Beaver Creek, as its western branch is called, also rises near Folsom, N. Mex., and flows through a wide, shallow valley in an easterly direction to its junction with Wolf Creek in Woodward County, and then in a southeasterly direction. The bed of this stream is wide and sand choked, and is from 100 to 200 feet below the level of the plains. It runs through red or gray sandstones and gypsum, none of which make good building material. The slope of the river decreases from 15 feet per mile at the New Mexico boundary to 7 feet per mile at Woodward.

IRRIGABLE LANDS.

In these counties there are several large tracts of first-class irrigable land. The river and creek valleys are generally several miles wide and contain rich alluvial soil, sometimes mixed with sand. Between the Cimarron and North Canadian, or Beaver, lies a rolling prairie 20 to 40 miles wide and 200 miles long, with a slope of 14 feet per mile to the east. In Beaver County the slope is toward Beaver Creek, and on account of the slight fall (100 to 150 feet) to the level of the creek this plain is not badly eroded; but in Woodward County the slope is 400 to 500 feet toward the Cimarron, erosion has been great, and the whole plain is intersected by canyons varying from 30 to 100 feet deep.

CANAL LINES.

Generally in this region canal lines along the south or west bank of any stream could be cheaply constructed, as there would be no rock excavation nor sand hills, and the cross slopes would be as a rule less than 8°, the only expensive feature being the crossing of drainage lines. The prevailing direction of high winds is from the south and southwest. These have carried sand from the wide, dry beds of the streams and have built up ridges of sand hills along the north and east banks. Some of these sand-blown hills are 70 feet high, and it is not uncommon to find them 5 or 10 miles from the river beds. These sand hills would make canal construction along the north and east banks very difficult and expensive.

WATER SUPPLY.

The water supply for an irrigation project here must come from either the Cimarron or North Canadian drainage basin. The flow of these streams is very low during the greater part of the irrigation season and is very variable from year to year. Therefore, as a source of supply for a project of uniform and permanent value this flow is negligible and a storage reservoir becomes indispensable. The valleys are generally wide and furnish ample reservoir capacity.

A storage reservoir may be located on the supplying stream, or in one of its tributary valleys, or in a natural depression or lake. The first of these is generally the cheapest, because it eliminates an inlet canal, which must be of sufficient capacity to carry the storm flow. But with better dam sites a tributary valley or a natural depression makes a preferable reservoir site.

WOLF CREEK.

Wolf Creek drains the northeastern part of the Texas panhandle and flows northeastward to Fort Supply, Okla., where it joins Beaver Creek and forms the North Canadian. The drainage area is 2,000 square miles and the slope in Oklahoma averages 8 feet per mile. It flows through a broad, shallow valley which was formerly from 2 to 4 miles wide, but which at present is broken by sand hills. There is no dam site on this stream, owing to (1) lack of building material, (2) lack of substantial abutments, (3) great width of valley, and (4) great depth of sand in river bed. Several wells in the river valley are 40 feet deep and penetrate sand throughout this depth. This stream during the past twelve years has only once been known to go dry, and then only for a very short time. Consequently, hydrographic surveys may show that a small irrigation project utilizing the natural flow is feasible. This would be within reach of private enterprise.

On February 24, 1905, the business men's association of Woodward petitioned the Secretary of the Interior to have a reservoir site on Wolf Creek investigated. For the reasons above stated a reservoir on this stream is impracticable.

NORTH CANADIAN RIVER.

The drainage area of the North Canadian above Woodward is approximately 10,000 square miles; nevertheless it frequently runs dry at Woodward during the summer months. The width of the valley, excluding the sand hills along the north bank, is nowhere less than 2 miles. The depth of sand in the river bed is great, and building material is extremely scarce.

All the tributaries of this stream flow through valleys of great and uniform width and lack building material. The larger tributaries, notably the Persimmon and Indian, carry considerable water during the irrigation season. This natural flow could be utilized by private parties at small expense.

On May 2 Samuel Tatlow petitioned the Secretary of the Interior to have a reservoir site on North Fork of Persimmon Creek investigated. The drainage area of this stream is less than 20 square miles, and on June 30 the discharge was 0.7 second-foot. The entire flow if stored would irrigate 600 to 700 acres and would flood 300 acres of first-class land.

BEAVER CREEK.

Beaver Creek drains the greater part of Beaver County and forms the northern fork of the North Canadian. It flows through a wide, shallow valley, nowhere less than 1 mile in width, in which there is no choke or dam site and in which the depth to an impervious stratum is more than 30 feet. West of range 10 (Cimarron meridian) the stream is usually dry, but east of this point it generally carries water.

The tributaries of this stream from the north are generally dry, but those from the south, notably the Palo Duro, Coldwater, Clear, and Kiowa, have a considerable flow. There is no dam site on these streams, the valleys being too wide and without chokes.

Although some of the water of both the main creek and its tributaries is being used for irrigation, still a good deal more could be done by private enterprise.

A natural basin in T. 5 N., R. 26 E., was investigated in order to determine whether Beaver Creek could be diverted into it. This basin will hold between 5,000 and 7,000 acre-feet, and is 180 feet above Beaver Creek, or 350 feet above the Cimarron. A canal, to carry the storm flow from Beaver Creek to this basin, would follow a sandy and badly washed sidehill and would necessarily be over 30 miles long, the slope of the creek being 8 feet to the mile. Furthermore, it is extremely doubtful whether this basin would hold water.

In secs. 30 and 31, T. 2 N., R. 19 E., Cimarron meridian, there is a shallow basin covering an area of 700 acres. This basin is 15 feet deep, but with a dam 2,000 feet long and 40 feet in maximum height the depth would be increased to 30 feet, and its storage capacity would approximately be 8,000 acre-feet. There is no rock in the basin, but a layer of clay underlies 18 inches of sandy soil. The rim is 90 feet higher than Palo Duro Creek, and it would require a canal 12 miles long to divert the storm waters from this creek into the basin. The length and size of the inlet canal, the length of the embankment, the limited storage capacity, and the losses due to seepage and evaporation make this project very expensive.

GARRETT PROJECT.

INVESTIGATION.

The drainage area of the Cimarron above Waynoka is approximately 10,500 square miles. East of Garrett, Okla., there is no dam site on this stream, owing to the great width of the valley, the depth of sand in the river bottom, and the lack of building material. The stream flows through two salt marshes in the northeastern part of Woodward County and, in addition to the above-named drawbacks, the water below these marshes is too salty to be used for irrigation. Buffalo Creek, the chief tributary of the Cimarron in Woodward County, was dry on July 6 and 7. This creek is flanked by gypsum and red-sandstone bluffs, but its valley is over 2,000 feet wide, and the rock is too poor to be used as building material or to form the abutments for a dam. Carriso Creek, the chief tributary of the Cimarron in Beaver County, flows through a wide valley in which good building material is plentiful. There are numerous mining claims on this stream, the possible value of which would materially add to the cost of a reservoir.

The gorge of the Cimarron between Garrett, Okla., and a point 6 miles west of Folsom, N. Mex., was explored for more favorable conditions than those existing at the Kenton site and cross sections were surveyed at all the narrow points. The following table gives the results of these surveys:

Dam sites on Cimarron River.

Location.	Average length of dam.	Extreme height of dam above river.	Drainage area.	Capacity.	Abutments and building material.
	Feet.	*Feet.*	*Sq. miles.*	*Acre-feet.*	
Sec. 1, T. 30 N., R. 27 E., New Mexico meridian.	700	100	65	10,000	Sandstone and lava.
T. 30 N., R. 31 E., New Mexico meridian	2,000	100	290	40,000	Do.
T. 5 N., R. 2 E., Cimarron meridian	2,500	80	1,500	65,000	Do.
Kenton	2,100	80	850	70,800	Do.
Garrett	1,800	80	2,100	58,200	Sandstone.

The table shows that the Kenton and Garrett sites have the most advantageous features. Considered solely as storage sites they are of equal value, the former having a longer dam but a correspondingly greater capacity. The advantages of an irrigation project at the Garrett site, however, are: (1) The drainage area is larger (2,100 square miles, as against 850); (2) the irrigable land is in a wider tract, consequently the cost of canal lines will be less. Below Kenton there is a gorge 25 miles long and 1 mile in average width, flanked by rock bluffs 70 to 200 feet high, whereas below Garrett the rock bluffs disappear and the average width of the valley is between 2 and 3 miles. The above advantages make this the most feasible project in northern Oklahoma, and in order to make a preliminary estimate a reconnaissance survey of the dam, the reservoir, and the canal lines was made, and a permanent gaging station was established.

RESERVOIR.

This reservoir is located chiefly in T. 5 N., R. 4 E., Cimarron meridian. Its capacity is as follows:

Capacity of Garrett reservoir.

Contour.	Area.	Capacity of section.	Total capacity.
Feet.	*Acres.*	*Acre-feet.*	*Acre-feet.*
4,200	74	370	370
4,210	234	1,540	1,910
4,220	418	3,260	5,170
4,230	652	5,350	10,520
4,240	910	7,810	18,330
4,250	1,182	10,460	28,790
4,260	1,476	13,290	42,080
4,270	1,752	16,140	58,220

The greater part of the land in the reservoir is patented, and if this is condemned in 40-acre tracts the area to be condemned would be 2,320 acres.

DAM SITE.

The dam site is located in the SW. ¼ of sec. 9, T. 5 N., R. 4 E., Cimarron meridian. The south abutment is a sandstone bluff 230 feet high, and the north abutment is a gradually sloping ridge on which sandstone outcrops at several places. A spillway 300 feet long could be readily excavated in a gap of this ridge and would discharge the overflow into the stream three-fourths mile below the dam. A masonry dam at this site to impound 58,220 acre-feet would contain 132,800 cubic yards, and a rock-fill dam with 1 to 1 upstream slope and 1 vertical to 1½ horizontal downstream slope, 15 wide at top and with a masonry core wall from 1 to 16 feet thick, would contain 497,000 cubic yards rock fill and 46,000 cubic yards of masonry.

CANAL LINES.

A canal line 42 miles long was surveyed along the south side of Cimarron River, starting at the reservoir site. Thirty-five miles of this canal were through firm ground having cross slopes of ½° to 6°, 3 miles were through sandy soil with cross slopes of ½° to 6°, 1 mile was through sand, and 3 miles were through rock of which one-half mile had cross slopes of 15° to 27° and the remainder 2° to 6°. This canal will control 36,000 acres, of which 12,000 are first-class irrigable land, 12,000 are second-class irrigable land, and 12,000 are either too high, too rocky, or too rough to be irrigated. It was originally intended to run this line so as to reach the wide area of irrigable land on the plains constituting the divide between the Cimarron and the Beaver, but after surveying 42 miles the line was still 50 feet below the plain, and the region through which it ran was getting very rough. This canal line crosses nine wide but shallow arroyos, across which the water will have to be carried in a flume or inverted syphon.

A canal line was also run along the north side of the Cimarron. This canal as soon as it leaves the river valley strikes a ridge of sand and loose-rock hills varying from 80 to 150 feet high in which construction would be very expensive; it will, therefore, have to skirt the base of these hills and with this location it will control 350 acres of irrigable land per mile of canal. Of the area controlled by these canal lines 9,120 acres are patented land; of this amount 80 per cent, or 7,300 acres, is irrigable land.

IRRIGABLE LAND.

Hydrographic records on which to base an estimate of the run-off of Cimarron River are not available, but it is fair to assume that the flow of the river during the nonirrigating season will fill the reservoir; that the flow during the irrigating season will exceed the losses due to seepage and evaporation, and that 2 acre-feet stored in the reservoir will irrigate 1 acre. With these assumptions this project will reclaim 30,000 acres. This land lies in T. 5 N., Rs. 4, 5, 6, 7, and 8 E., Cimarron meridian. Twelve thousand acres of the irrigable land will be in the river bottom, and will require little work to prepare it for irrigation; the remaining 18,000 acres have considerable slope and will require terraces or checks to prevent erosion. The bottom lands in this region will yield fair crops of Kaffir corn, milo maize, and wild hay without irrigation; the bench lands are fine grazing lands, but will not yield a crop. With irrigation they will all yield fine crops of alfalfa, corn, wheat, or fruit. On account of the adjacent excellent range lands, which extend for miles to the north and south, the chief product would be forage crops. Clayton, N. Mex., on the Colorado and Southern Railroad, is the nearest railroad depot and is 50 miles from Garrett; this distance from a railroad would also tend to make this the center of a stock-raising region.

PUMPING.

A head of 100 feet may be obtained from a canal line 11 miles long, but all the irrigable land not controlled by the gravity canals is 400 feet above the river, and since all the water for power must be stored pumping is not a practical proposition.

SUMMARY.

A masonry dam 4,000 feet long and 85 feet high at a maximum can be constructed on good bed rock. Half of this length would be a low wall from 5 to 10 feet in height. A high bluff of good sandstone is convenient, and would furnish material for a masonry or rock-fill dam. There is also a natural spillway on the north side of the river at an elevation suitable for maintaining a water depth of 75 to 80 feet in the reservoir. The maximum storage capacity would be 58,000 acre-feet. Sixty miles of main canal would supply water to 30,000 acres of good land, and the water supply would not be sufficient for more than this area. This project is too expensive for serious consideration.

OPERATIONS IN OREGON.

By JOHN T. WHISTLER.

EARLIER INVESTIGATIONS.

Preliminary examinations in various parts of the State were made in 1903, followed in the same year by preliminary surveys for the Malheur, Harney, and Umatilla projects. In 1904 more complete surveys were made for the Malheur project and further surveys and investigations for the Umatilla project. During this year preliminary surveys were made also for certain projects in the central part of the State. These examinations and surveys have been referred to at length in the Second Annual Report of the Reclamation Service, pages 433 to 444, and in the Third Annual Report, second edition, pages 463 to 476.

MALHEUR PROJECT.

LOCATION AND GENERAL DESCRIPTION.

The land to be served by the Malheur project is located in the east-central part of the State, along Malheur and Snake rivers. The irrigation of about 100,000 acres of bench and bottom lands is proposed, by storage in the Harper reservoir and diversion at the mouth of the Malheur Canyon directly onto the western extremity of the irrigable area. The elevation of the irrigable lands is from 2,150 to 2,350 feet above sea level.

Preliminary investigations and surveys were made in 1903, followed by more complete surveys in 1904. The results have been printed in the second and third annual reports. The surveys of the Harper reservoir site show that a dam about 175 feet high will impound nearly double the average run-off of the river, and at the same time make available a natural spillway site. The extreme variation in total discharge of the Malheur requires the storage of considerably more than the average run-off of the river, in order to provide an assured water supply for all years.

EARLIER SURVEYS.

From surveys made in 1903 it appeared that about 75,000 acres, including land at present irrigated, could be brought under the project by a diversion at the mouth of the Malheur Canyon, about 12 miles above Vale. More complete surveys in the following year, together with increased data as to the run-off of Malheur River, show that the area may be increased to 100,000 acres.

SURVEYS DURING 1905.

During the past year the only fieldwork done has been the examination and survey of two possible reservoir sites in the upper Malheur watershed, survey and investigation of the possible diversion of Bully Creek into the Harper reservoir, and the development of a few minor areas of topography, the necessity for which became apparent in making up the estimates based on surveys during the year 1904.

WATER SUPPLY.

The gaging station on Malheur River at Vale was maintained at intervals prior to May, 1903, by the United States Geological Survey. The station was established in 1890, and prior to the investigations of the Reclamation Service a total record of a little over three years was obtained. Since then two to four stations have been maintained on this river, and a total record of nearly six years is now available for the discharge at Vale. The total run-off available for this project in 1904 was over 800,000 acre-feet. For the present year it is estimated that the total run-off which would be available will amount to little over 200,000 acre-feet. The minimum discharge recorded is that for 1890, when but 140,000 acre-feet was recorded at Vale. Including the run-off of the present year, which is generally considered by those who have lived in this locality longest to have been unusually low, it is now estimated that the average run-off available will amount to not less than 350,000 acre-feet.

In conformity with an irrigation act passed by the legislature of Oregon (see pages 306-308), the State engineer was notified May 18, when the law became effective, that the United States intends to utilize all unappropriated waters of Malheur River. These waters are therefore not subject to further appropriation.

Cable gaging stations are being maintained on Malheur River at Vale, below the mouth Bully Creek, and at the Harper reservoir site. This latter station will be moved to the mouth of Malheur Canyon at the proposed diversion-dam site, on account of the impracticability of maintaining an observer at the present station. Bridge stations are also being maintained between these two stations and at a point about halfway between Vale and the mouth of Malheur River. Stations are also maintained on Bully Creek.

Since the beginning of the season of 1904 the entire time of one man has been given to measurements of the use of water in the various ditches taking water from Malheur River below the proposed reservoir, and a study of the use of water in order to determine the duty of water in this project and other data necessary to the proper design of the canals and distributary system.

ESTIMATE OF COST.

Earlier estimates of cost were based on the actual cost of construction, exclusive of maintenance and necessary drainage. In May of the present year a project board of engineers, consisting of Messrs. A. P. Davis, D. C. Henny, and John T. Whistler, considered the estimates prepared and recommended that the project be authorized at a cost of not to exceed $40 per acre for construction, maintenance, and drainage, and that an actual charge of not to exceed $2 per acre might be made for the purchase of the existing ditches and their water rights, if it should later be necessary or desirable.

VALUE OF LANDS.

As improved and irrigated lands in the Malheur Valley, with the imperfect water supply available for most of them, now sell for $100 or more per acre, there appears to be a good margin between the value of land with good water supply and the estimated cost of not to exceed $42 per acre for this project. Examinations by the soils engineers show that little or none of the land need be excluded from the project on account of quality of soil.

UNPATENTED LANDS AND EXCESS HOLDINGS.

About 85 per cent of the land under this project is patented. Of these patented lands about 25,000 acres are owned by a foreign syndicate, known as the Road Lands Company, as a part of the Willamette Valley and Cascade Mountains military road grant, extending from eastern Oregon through central Oregon and across the Cascade Mountains to the Willamette Valley. With the exception of the lands held by this company, there are comparatively few excess land holdings. Up to the present time the company has not agreed to submit its lands to the project on conditions satisfactory to the Government.

WITHDRAWALS.

Unpatented lands covering reservoir and diversion sites have been withdrawn from all entry. Unpatented irrigable lands have been withdrawn from all except homestead entry under the reclamation act.

WATER USERS' ASSOCIATION.

In September, 1904, the owners of patented land organized the Malheur Water Users Association to undertake the adjustment of the present vested water rights and other matters incident to furthering the proposed project by the Government. This association was organized with $30 as the par value of a share of stock, based on the earlier preliminary estimates of cost of project per acre, as referred to above. A reorganization will now be necessary, but will probably not be made until the Road Lands Company comes to an agreement in regard to the inclusion of its lands.

OWYHEE PROJECT.

LOCATION AND GENERAL DESCRIPTION.

The irrigable lands under the Owyhee project lie immediately south of the area covered by the Malheur project and extend south along Snake River to and including the lands about the mouth of Sucker and Jump creeks, Idaho. Owyhee River empties into the Snake about 20 miles above the mouth of the Malheur. The elevation of these lands is the same as that of those included in the Malheur project—2,150 to 2,250 feet above sea level.

Owyhee River flows for the most part through a canyon from 200 to 400 feet or more in depth, and no diversion can be made to cover any large body of land on either side, except by the construction of a high diversion dam at the mouth of the Owyhee Canyon, about 15 miles above the mouth of the river. With such a dam it would be possible to cover a large part of the lands now proposed to be irrigated under the Malheur project. The two projects are therefore closely related, and have been considered together.

EARLIER SURVEYS.

A preliminary examination for this project was made early in 1903 and reported on in connection with the Malheur project. Further investigation and surveys were not at that time recommended, but on account of the later estimated cost per acre of the Malheur project and the possibility that the so-called Road Lands Company might not submit its lands under that project, it appeared desirable this year to extend the investigations for the Owyhee project.

SURVEYS IN 1905.

During the latter part of 1904 the irrigable-land surveys for the Malheur project were extended to include a few thousand acres lying south of Owyhee River. A rapid reconnaissance line was also run to determine what area farther south might be included in the Owyhee project, if a higher diversion dam should be found practicable. During the past year all the remaining lands south of the Owyhee—about 35,000 acres—were mapped on a scale of 2,000 feet to 1 inch; surveys were made of a possible reservoir site on Sucker Creek to supplement the Owyhee water supply by serving lands otherwise too high, and diamond-drill borings were made at the proposed diversion-dam site and at the two reservoir-dam sites locally known as Red Butte and Duncans Ferry, the former about 50 miles above the mouth of the river and the latter perhaps 100 miles above. Borings at the diversion site show a fair foundation for a masonry dam at a depth of not over 25 feet below the river bed. Borings at the Red Butte dam site developed rock at about the same depth, but of poor quality for a masonry-dam foundation. Borings for a spillway site at this latter place also showed that the underlying material consists of bowlders and clay to a great depth. Borings at the Duncans Ferry site developed a good foundation for a masonry dam at practically the level of the river bed. Preliminary alternative estimates have been made as surveys and boring work progressed, but completed estimates can not be made for some time.

WATER SUPPLY.

The annual discharge from Owyhee River considerably exceeds that of the Malheur. Between 5,000 and 6,000 acres are at present irrigated from the Owyhee. This represents about the limit of the area irrigable without storage.

A gaging station has been maintained on Owyhee River at intervals since 1894. Careful measurements and records of the use of water through the Owyhee ditch are being made by the hydrographer carrying on the same work under the Malheur project. This ditch is practically the only diversion from Owyhee River below the mouth of the canyon.

UNPATENTED LANDS AND EXCESS HOLDINGS.

A very small portion of the area which can be irrigated from Owyhee River, whether confined to the areas south of the river or extended north to cover part of the present Malheur project, is unpatented. Some 5,000 or 6,000 acres of land under the project, if extended north only to the limit of the present proposed Malheur project, are owned by a company holding lands of The Dalles military road land grant.

WITHDRAWALS.

All irrigable lands on the north side of the Owy [illegible] been withdrawn from all except homestead entry under the Malheur project. Those on the south side in Oregon have been withdrawn from all entry under the Owyhee project. The irrigable lands under the project in Idaho have not been withdrawn, as from the records there appears to be little or no land still unpatented. The lands for both the Red Butte and Duncans Ferry reservoir sites have been withdrawn from all entry.

WILLOW CREEK PROJECT.

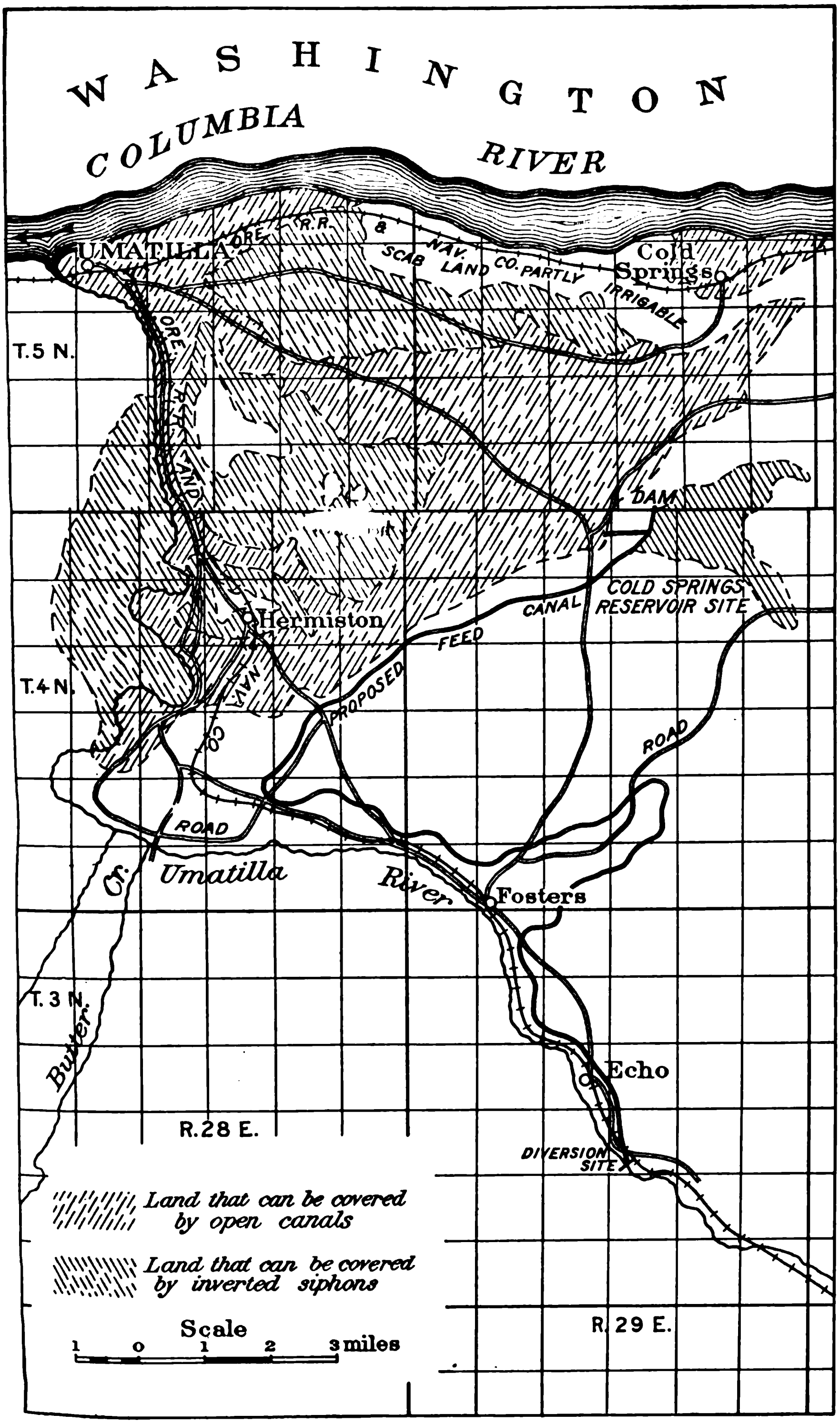
In connection with the Malheur, the Willow Creek project has been considered. The discharge of this creek is extremely irregular, and a final consideration of the project can not be given until discharge measurements have been made for several years. This project has been referred to at length in the Third Annual Report, second edition, pages 465 and 466.

UMATILLA PROJECT.

LOCATION AND GENERAL DESCRIPTION.

The Umatilla project has heretofore contemplated the irrigation of a portion of the large area of irrigable lands lying between Willow Creek and Umatilla River and bordering on Columbia River (Pl. XLIX). Earlier investigations and surveys have been referred to at length in the Second Annual Report, pages 433 and 434, and in the Third Annual Report (second edition), pages 468 and 469.

During the latter months of 1904 surveys developed a good reservoir site, referred to as the Carty reservoir site, in T. 2 N., Rs. 24 and 25 E., immediately southwest of the abandoned Juniper reservoir site, referred to in Third Annual Report. About the same time a comparatively low pass was found in T. 1 N., Rs. 19 and 20 E., through which it would be possible to divert the waters of John Day River and cover practically all of the irrigable land west of Umatilla River, about 200,000 acres. Only a few preliminary lines were run, but sufficient information was obtained to demonstrate the feasibility of such a project, though at a probable high cost per acre. It would require the use of the Carty reservoir site and probably an additional site in Tps. 8 and 9 S., Rs. 24 and 25 E., known as the Spray reservoir site.



GENERAL MAP OF PROPOSED UMATILLA PROJECT, OREGON.

WATER SUPPLY.

The run-off of John Day River is about five or six times that of the Umatilla. A gaging station has been maintained about 15 miles above the mouth of the river since October, 1904. Unchecked records of measurements at this station show that not less than 1,250,000 acre-feet were discharged during the past year.

In conformity with the laws of the State (see pp. 306–308), the State engineer was notified on September 6 that the United States intends to utilize all unappropriated waters of Umatilla River. These waters are therefore not subject to further appropriation.

UNPATENTED LANDS.

By a ruling of the Department of the Interior since the publication of the Third Annual Report, the Northern Pacific Railway grant has been considerably increased, and the unpatented land coming under the project will but little, if at all, exceed one-third of the total area.

WITHDRAWALS.

Besides the lands withdrawn, as referred to in the Third Annual Report, additional lands which may be irrigated in part, and also lands for the Spray reservoir site and covering John Day Canyon from the point of diversion, have been withdrawn from all forms of entry.

EAST UMATILLA PROJECT.

LOCATION AND GENERAL DESCRIPTION.

Owing to the great length of feed canal necessary for supplying the Carty reservoir from Umatilla River, under the Umatilla project, and also because of the desirability of maintaining the lands west of Umatilla River free from any construction which would increase the acre cost of a future project from John Day River, investigations were made early in the present season for a possible small project for the lands on the east side of Umatilla River and bordering on the Columbia.

A small reservoir site, lying principally in the NE. corner of T. 4 N., R. 29 E., was investigated. This would have 40,000 to 50,000 acre-feet capacity, by the construction of an embankment 70 to 80 feet high. Lying below are some 20,000 acres of irrigable land, at an elevation of from 300 to 550 feet above sea level, which can be supplied from this reservoir.

WATER SUPPLY.

Records of stream measurement on Umatilla River at Gibbon since 1896 and at additional stations on the river since 1903 show that an ample supply of water is available, with a comparatively small feed canal.

PROGRESS OF WORK.

During the past season a general topographic map on a scale of 1½ miles to 1 inch has been made of the entire irrigable area, both of the larger Umatilla project from John Day River and of the East Umatilla project from the Umatilla. Topographic surveys have been made of the reservoir site on a scale of 1,000 feet to 1 inch, and the detail topography developed of the dam site and feed-canal lines on a scale of 100 and 400 feet to the inch. Test pits have been put down over the larger part of the embankment line and at the proposed spillway site. Bed rock is encountered at the dam site at a depth of 22 to 25 feet below the surface. From these surveys estimates of quantities and cost are being prepared for the consideration of a board of consulting engineers.

Studies are also being made of the use of water through the existing ditches taking water from Umatilla River, in order to determine the rights of the Government to use the water under the project, and also for use in any adjudication of water rights which may be required

A hydrographic map on a scale of 1,000 feet to 1 inch is being made of the lands and irrigation system below the proposed diversion. The measurement of ditches and collection of other data relating to use of water from Umatilla River above this point is being done by the State engineer at the expense of the State.

UNPATENTED LANDS AND EXCESS HOLDINGS.

Of the total area of irrigable land under the project less than 1,000 acres remain unpatented or not entered. Each odd section of land is either patented to or claimed by the Northern Pacific Railway Company under railroad grant. Other lands have been entered in a few cases by homestead entries, but generally by desert-land entries, planning to reclaim the lands by water from one of several ditches either proposed or partly constructed. Of these latter the Maxwell Land and Irrigation Company owns the most extensive, and with other rights has acquired by purchase the title to between 8,000 and 9,000 acres of land which would come under the proposed Government project. Negotiations are being carried on with the several excess landowners looking toward the acquirement of their rights, and an agreement on their part to subscribe their excess holdings. Withdrawals from all entry have been made for lands covering the reservoir site and irrigable lands.

CENTRAL OREGON PROJECTS.

The Silver Creek, Chewaucan, Ana River, Silver Lake, and Odell and Crescent lakes projects, in central Oregon, have been referred to at length in the Third Annual Report, second edition, pages 471 to 486.

No further investigations have been made during the past season of these projects, except for the Silver Lake project, in which an examination was made as to the feasibility of diverting across the divide to the north into Silver Creek some of the streams which now empty into the Sycan Marsh. This appeared feasible, but little information is available as to the discharge of these streams. Practically no data could be had as to the discharge of the streams of central Oregon prior to the summer and fall of 1904, when gaging stations were established on all the streams affecting these projects. Owing to the time and expense involved in making frequent trips into this part of the State, a hydrographer has been stationed at Silver Lake, and gives his entire time to the work at this and certain other stations.

COOPERATION WITH THE STATE.

The Oregon State legislature on February 16, 1904, passed an irrigation act, providing, among other things, for cooperation with the United States in hydrographic and topographic surveys and in the construction of works for the development and use of the water supply of the State.

The following is a copy of the law, which became effective on May 18:

SECTION 1. *Appropriation of water.*—Any person, association, or corporation hereafter intending to acquire the right to the beneficial use of any waters for the reclamation of arid lands shall post in a conspicuous place at the proposed point of diversion a written or printed notice containing the name of such applicant and the stream or other source of supply of such water, a brief description of the point of diversion and the nature of the beneficial use to which such waters are to be applied, and the exact date of posting, and shall within fifteen days thereafter file in the office of the clerk of the county in which such notice is posted a duplicate thereof so attested, and shall within thirty days thereafter file in the office of the State engineer a certified copy of such duplicate as filed in the office of the county clerk, which shall be accompanied by such information, maps, field notes, plans, and specifications as may be necessary to show the method of construction. All such maps, field notes, plans, and specifications shall be made from actual surveys and measurements, and shall be retained in the office of the State engineer: *Provided*, That appropriation of water by the United States shall be made as provided in section 2.

SEC. 2. *Appropriation of water by United States.*—Whenever the proper officers of the United States authorized by law to construct works for the utilization of water within this State, shall file in the office of the State engineer a written notice that the United States intends to utilize certain specified waters, the waters described in such notice and unappropriated at the time of the filing thereof shall not be subject to further appropriation under the laws of this State, but shall be deemed to have been appropriated by the United States: *Provided*, That within a period of three years from the date of filing such notice the proper officer of the United States shall file final plans of the proposed works in the office of the State engineer for his information: *And provided further*, That within four years from the date of such notice the United States shall authorize the construction of such proposed work. No adverse claims to the use of the water required in connection with such plans shall be acquired under the laws of this State except as for such amount of said waters described in such notice as may be formally released in writing by an officer of the United States thereunto duly authorized, which release shall also be filed in the office of the State engineer. In case of failure of the United States to file such plans or authorized construction of such works within the respective periods herein provided, the waters specified in such notices, filed by the United States, shall become subject to appropriation by other parties. Notice of the withdrawal herein mentioned shall be published by the State engineer in a newspaper published and of general circulation in the stream system affected thereby, and a like notice upon the release of any lands so withdrawn, such notices to be published for a period not exceeding thirty days.

SEC. 3. *Adjudication of water rights.*—In any stream system where construction is contemplated by the United States under the act of Congress approved June 17, 1902, and known as the reclamation act, the State engineer shall make a hydrographic survey of such stream system, and shall deliver an abstract thereof, together with an abstract of all data necessary for the determination of all rights for the use of the waters of such system, to the attorney-general of the State. The attorney-general, together with the district attorneys of the district affected by such stream system, shall, at the request of the Secretary of the Interior, enter suit on behalf of the State of Oregon, in the name of the State, for the determination of all rights for the use of such waters, and shall diligently prosecute the same to a final adjudication.

SEC. 4. *Parties and costs of suits.*—In any suit wherein the State is a party, for the determination of a right to the use of the waters of any stream system, all who claim the right to use such waters shall be made parties. When any such suit has been filed the court shall call upon the State engineer to make or furnish a complete hydrographic survey of such stream system as hereinbefore provided, in order to obtain all data necessary to the determination of the rights involved. The disbursements made in litigating the rights involved in such suit shall be taxed by the court as in other equity suits.

SEC. 5. *Decrees adjudicating water rights.*—Upon the adjudication of the rights to the use of the water of a stream system, a certified copy of the decree shall be prepared by the clerk of the court, without charge, and filed in the office of the State engineer. Such decree shall in every case declare, as to the water right adjudged to each party, whether riparian or by appropriation, the extent, the priority, amount, purpose, place of use, and, as to water used for irrigation, the specific tracts of land to which it shall be appurtenant, together with such other conditions as may be necessary to define the right and its priority.

SEC. 6. *State engineer, appointment, duties, qualifications, and salary.*—A State engineer, technically qualified and experienced as an hydraulic engineer, shall be appointed by the governor upon the recommendation of the director of the United States Geological Survey and confirmed by the senate. He shall hold office for the term of four years from and after his appointment, unless sooner removed by the governor for cause, and until his successor shall have been elected and shall have qualified. He shall have general supervision of all the measurements and records of appropriation of waters of the State, and of all surveys and engineering work in which the State may be interested, and for which funds are provided, and shall perform all work in connection therewith. He shall receive a salary of $2,400 per annum and actual and necessary traveling expenses while away from his office in the discharge of official duties, and shall not engage in private practice. He may employ assistants and purchase materials and supplies necessary for the proper conduct and maintenance of his office and department, in pursuance of appropriations as made from time to time for such purposes. The salaries and expenses of the office of the State engineer shall be paid at the same time and in the same manner as those of other officers of the State. The office of the State engineer shall be located at the seat of government in the capitol building. The State engineer and his authorized assistants and agents may enter upon any private property for the performance of their respective duties, doing no unnecessary injury thereto. The State engineer shall prepare and deliver to the governor on or before November 30 of the year preceding the regular session of the legislature, and at other times when required by the governor, a full report of the work of his office, including a detailed statement of the expenditures thereof, with such recommendations for legislation as he may deem advisable.

SEC. 7. *Oath and bond of State engineer.*—Before entering upon the duties of his office the State engineer shall give bond to the State with sufficient sureties in the sum of $5,000 for the faithful performance of his duties, which bond shall be approved by and filed in the office of the secretary of state, together with the following oath of office: "I, ——— ———, being duly sworn, do say that I am the duly appointed State engineer of the State of Oregon, and that I will faithfully and honestly perform the duties of such office, and that I am not directly or indirectly, pecuniarily, or otherwise interested with any person, association, or corporation using or to use any of the waters of the State for any beneficial purpose, in such use thereof, and will not during my term of office become so interested therein or receive any pecuniary aid or benefit therefrom, and shall not permit any assistant employed by me to be or become so interested or receive any pecuniary aid or benefit from such person, association, or corporation while so employed."

SEC. 8. *Records of State engineer.*—The records of the office of the State engineer are public records and shall remain on file in his office and be open to the inspection of the public at all times during business hours. Such records shall show in full all maps, profiles, and engineering data relating to the use of water, and certified copies thereof shall be admissible as evidence in all cases where the original would be admissible as evidence.

SEC. 9. *Fees of State engineer.*—The State engineer shall receive the following fees, to be collected in advance, and to be paid by him into the general fund of the State treasury on the last day of March, June, September, and December of each year:

(*a*) For filing and recording notice of an appropriation of water, map, and field notes of the same, $5.

(*b*) For blueprint copy of any map, drawing, 10 cents per square foot or fraction thereof. For other copies of drawings or any data furnished upon application, actual cost of work.

(*c*) For certifying to such copies, $1 for each certificate.

(*d*) For such work as may be required of his office, the fees provided by law.

SEC. 10. *Hydrographic and topographic surveys and cooperation with the United States Government.*—The State engineer shall make hydrographic and topographic surveys and investigations of each stream system and source of water supply in the State, beginning with those most used, obtaining and recording all available data pertaining to the water supply of this State. He is hereby authorized to cooperate with the agencies of the United States Government engaged in similar surveys and investigations, and in the construction of works for the development and use of the water supply of this State, expending for such purposes any money available for the work of his office.

For the purpose of making hydrographic and topographic surveys, there is hereby appropriated out of any moneys in the treasury not otherwise appropriated the sum of $2,500 annually for such hydrographic and $2,500 annually for such topographic surveys, such appropriations, however, being contingent upon the United States Government making a like apportionment for such purposes to be expended within the State.

SEC. 11. *Disposition of State lands.*—No lands belonging to the State, within the areas to be irrigated from work constructed or controlled by the United States or its duly authorized agents, shall hereafter be sold except in conformity with the classification of farm units by the United States, and the title of such land shall not pass from the State until the applicant therefor shall have fully complied with the provisions of the laws of the United States and the regulations thereunder concerning the acquisition of the right to use water from such works, and shall produce the evidence thereof duly issued. After the withdrawal of lands by the United States for any irrigation project, no application for the purchase of State lands within the limits of such withdrawal shall be accepted, except under the conditions prescribed under that section. Any State lands needed by the United States for irrigation works shall be conveyed to the United States without charge.

SEC. 12. *Right of way over State lands.*—There is hereby granted over all the unimproved lands now or hereafter belonging to the State the necessary right of way for ditches, canals, and reservoir sites for irrigation purposes constructed by authority of the United States or otherwise. All conveyances of State land hereafter made shall contain a reservation of such right of way and reservoir sites.

SEC. 13. *Appropriations.*—There is hereby appropriated out of the moneys in the general fund of the State treasury, not otherwise appropriated, the sum of $5,000 annually, or so much thereof as may be necessary, for the salary and expenses of the State engineer and the services of assistants and expenses of the office and department of the State engineer.

SEC. 14. But nothing in this act shall be construed as rescinding the cession by the State to the United States of lands as provided in the act known as house bill No. 1, passed by the twenty-third regular session of the Oregon legislature.

Filed in the office of the secretary of state February 22, 1905.

As provided in section 6 of this act the Director of the Geological Survey recommended to the governor of Oregon, for appointment as State engineer, Mr. John H. Lewis, assistant engineer in the Reclamation Service. His appointment was made by the governor on May 18.

Under the provisions of section 10 of this act, in addition to cooperation with the United States Geological Survey in topographic and stream-gaging work, the State engineer has directed that a part of the hydrographic work in connection with the East Umatilla project be done at the expense of the State.

OPERATIONS IN SOUTH DAKOTA.

By C. H. Fitch.

GENERAL STATEMENT.

A reconnaissance of the western part of South Dakota was made during the summer of 1903, looking toward the future development of the farming interests of this region and the reclamation of the valley lands, which are semiarid.

All streams which gave any indication of a water supply sufficient for reclamation on an extensive scale were examined and gaging stations established thereon, so that a careful study could be made of their run-off and of the amount available over that already appropriated, if any. Daily gage heights have been since taken and the results published each year in progress reports of the hydrographic branch of the United States Geological Survey.

A number of possibilities for reclamation were found and reported on, but it was thought best to concentrate present work on the most promising for immediate returns. The reclamation of part of the Belle Fourche Valley was selected, and detail surveys were begun in the spring of 1904 and construction in the spring of the present year.

Other localities are being watched and as the money becomes available will doubtless receive attention. It is probable that in time the irrigable area of this State may be increased from the 20,000 acres it has to-day to 300,000.

The present year has been one of abnormal rainfall, and while the moisture has been sufficient and so distributed as to produce crops in some parts of the State without irrigation, it is the first year for some time that this has been the case. A trip through the country will show an observer how the application of 18 inches of water can change the desert lands into profitable farms.

BELLE FOURCHE PROJECT.[a]

The Belle Fourche project contemplates the irrigation of a body of semiarid land adjacent to what is universally known as "the richest 100 square miles on earth"—the rich gold-mining region of the Black Hills, where much of the produce raised under the project will be consumed. The nature of the investigations leading up to construction is fully explained in the Third Annual Report of the Reclamation Service, 2d edition, pages 477 to 484.

In general, this work contemplates the diversion of the waters of Belle Fourche River at a point below the mouth of the Redwater, and the storage of the same in a large reservoir to be formed by a dam across Owl Creek just below the mouth of Dry Creek, about 10 miles northeast of the town of Belle Fourche, S. Dak. This reservoir will hold sufficient water for the complete irrigation of all lands in the project. (Pl. L.)

Canals of sufficient capacity to furnish water to all the Government, State, and private lands that are now signed up under them will be constructed from the reservoir as far as the Willow Creek divide on the north side and Ninemile Creek on the south side of Belle Fourche River, and from these main canals laterals will lead the water down the divides to each farm unit. All lands will be under the reservoir except the small area under the supply canal,which will always have a sufficient supply from the river.

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[a] From report by R. F. Walter.

SUPPLY CANAL.

The supply canal which will carry the waters of the Belle Fourche to the reservoir is under construction. (Pl. LI, *A*.) It will be 6½ miles long and 40 feet wide on the bottom and will carry a depth of water of 10 feet, with a grade of 1 foot to the mile. The side slopes are 1 to 1 through cuts and 1½ to 1 on sidehill work and on banks. The banks are 8 feet wide on top and will be 3 feet above high-water line after settlement. The theoretical capacity is 1,635 second-feet. The canal heads about 1½ miles below the town of Belle Fourche and enters the reservoir through a 43-foot cut on the west side.

DIVERSION DAM AND REGULATOR.

The grade of the canal is 8 feet above low water in the Belle Fourche, and the necessary raise of the water in the river to this grade is accomplished by a concrete diversion dam in the river, 400 feet long, built in the form of an overflow weir connected with the regulator and provided with sluice gates adjacent to the regulator gates. Provision is made for floods of 20,000 second-feet to pass over the weir before the flood line is reached.

The dam is of gravity section and founded on a slate or shale rock, which the borings indicate is continuous to a great depth. A cofferdam of steel sheet-piling was first driven around the dam site and a careful connection made of the concrete weir into the slate. An earthen wing dam was connected with the overflow weir and extended across the valley, opposite the canal heading, to cut off any flood flow encountered. This earth dike will be riprapped with a wall of 18-inch rock.

The regulator piers and walls are founded on the slate and built of concrete. They are provided with seven 5 by 10 foot iron gates regulated with ball-bearing pedestals on the gate bridge, the sluice gates in the dam being the same pattern.

FLOODED AREA.

The construction of the diversion dam in the river will produce a permanent lake located between the dam and the town of Belle Fourche. The area of this lake when the canal is running full will be 170 acres, which will decrease as the flow of the river falls below 1,635 second-feet. No storage of water in this lake is contemplated.

CROW CREEK SLUICE AND FLOOD GATES.

Crow Creek is crossed about one-half mile below the head of the canal, and as it carries during the year a large amount of unappropriated water, which is available for storage, it is so arranged that this water can be taken into the canal. To guard against floods in Crow Creek a concrete overflow weir 180 feet long is constructed in the lower bank to act automatically when the canal is full. Three sluice gates, 5 by 10 feet each, are placed below the grade of the canal and will keep this section of it free from sediment.

DROP INTO RESERVOIR.

On account of the danger from erosion by dropping 1,635 second-feet of water from the supply canal into a partially filled reservoir, a semicircular weir 180 feet long is to be constructed at the end of the canal, with a maximum depth of water over its crest of only 2 feet. This weir will regulate the velocity in the canal above. It is founded on slate or shale rock.

CONTRACTS.

Bids were opened in Denver, Colo., April 10, 1905, for the supply canal and appurtenances, the work being divided into two schedules. No. 1, for all concrete structures, was awarded to S. R. H. Robinson, of St. Louis, Mo. Work on the same has been prosecuted continuously since the award and the diversion dam and regulator will probably be completed by winter. Schedule No. 2, for the canal excavation, was awarded to the Widell-Finley Company, of Chicago, Ill., who will complete the same by the summer of 1906.

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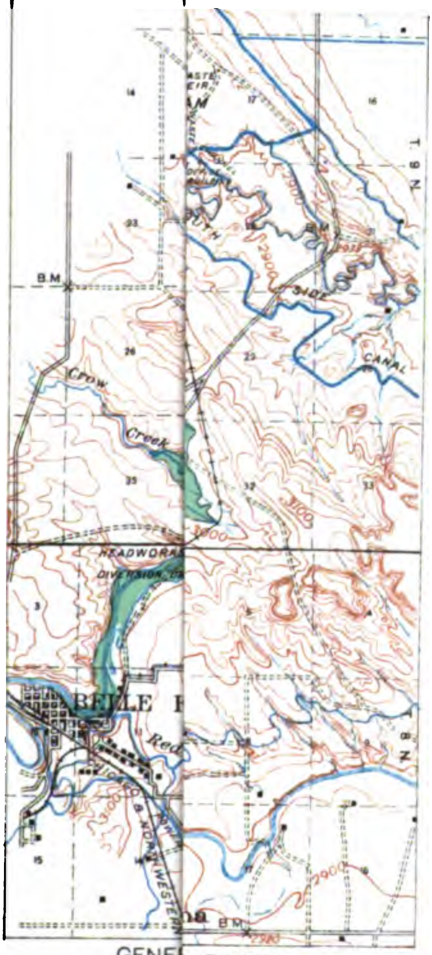

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Bids received for main supply canal, Belle Fourche project, South Dakota.

SCHEDULE No. 1.—DIVERSION DAM, REGULATOR, SLUICE, AND DROP, COMPLETE.

Bidder.	Concrete (11,000 cubic yards).	Paving, 18 inches thick (6,900 square yards).	Riprap (1,250 square yards).	Cast-iron gates, grooves in place (56,000 pounds).	Pedestals, stems and screws in place (14).	Structural steel in place (46,200 pounds).
S. R. H. Robinson, St. Louis, Mo	$4.95	$2.18	$2.50	$0.05	$70.00	$0.04¾
Jas. Munn & Edward Hanschka, Deadwood, S. Dak	4.95	2.70	2.50	.05	100.00	.055
Carroll Contracting Co., St. Louis, Mo	5.50	2.00	5.00	.08	150.00	.075
Henry Wyttenbach, Sturgis, S. Dak	5.65	1.75	1.28	.09	250.00	.075
Faris-Keel Construction Co., Boise, Idaho[a]	4.50	3.25	2.35	.07	105.00	.07
Orman & Crook, Pueblo, Colo	6.25	2.50	2.00	.09	75.00	.06
Widell-Finley Co., Mankato, Minn	6.75	2.75	2.95	.05	35.00	.055
W. C. Bradbury, Denver, Colo	5.85	4.40	3.80	.07½	104.00	.059
Phalen & Shirley, Callahan Bros. & Katz, Omaha, Nebr	6.50	3.50	3.50	.09	265.00	.08
Bates & Rogers Contracting Co., Chicago, Ill	7.45	2.75	2.00	.09	75.00	.09
Deeks & Deeks, St. Paul, Minn	7.30	2.50	2.50	.10	300.00	.08
Winters, Parsons & Boomer, Spokane, Wash	7.50	2.70	2.25	.10	300.00	.08
Kilpatrick Bros. & Collins Contracting Co., Beatrice, Nebr	8.91	3.21	2.97	.07	109.00	.09
Burrell Construction Co., Oakland, Cal	7.00	4.00	3.00	.05	350.00	.06
Keltie Contracting Co., Joliet, Ill	6.50	7.00	3.00	.08¾	325.00	.10

Bidder.	Steel sheet piling, 22 feet long (500 linear feet).	Excavation foundation under water (3,000 cubic yards).	Excavation foundation above water (7,000 cubic yards).	Native lumber (70,000 feet B. M.).	Driving and pulling sheet piling 5 feet deep (1,500 linear feet).	Total.
S. R. H. Robinson, St. Louis, Mo	$26.00	$1.50	$0.30	$18.50	$0.30	$99,936.50
Jas. Munn & Edward Hanschka, Deadwood, S. Dak	23.00	1.50	.22	20.00	1.50	104,136.36
Carroll Contracting Co., St. Louis, Mo	1.60	2.16	.44	32.00	1.10	104,845.00
Henry Wyttenbach, Sturgis, S. Dak	24.00	1.25	.50	22.00	.60	109,520.00
Faris-Keel Construction Co., Boise, Idaho[a]	34.65	2.50	.50	60.00	4.00	122,011.50
Orman & Crook, Pueblo, Colo	32.00	1.00	.25	35.00	1.25	122,437.00
Widell-Finley Co., Mankato, Minn	28.00	1.50	.35	30.00	1.00	127,293.50
W. C. Bradbury, Denver, Colo	23.00	1.75	.20	33.00	4.50	134,911.80
Phalen & Shirley, Callahan Bros. & Katz, Omaha, Nebr	25.30	1.00	.30	35.00	2.50	136,421.00
Bates & Rogers Contracting Co., Chicago, Ill	27.50	.75	.60	40.00	4.80	143,873.00
Deeks & Deeks, St. Paul, Minn	52.80	2.50	.50	35.00	.60	154,921.00
Winters, Parsons & Boomer, Spokane, Wash	52.80	2.00	.50	34.00	.50	156,468.50
Kilpatrick Bros. & Collins Contracting Co., Beatrice, Nebr	26.24	2.00	.25	25.00	1.50	158,345.50
Burrell Construction Co., Oakland, Cal	30.00	3.00	2.00	35.00	4.00	165,272.00
Keltie Contracting Co., Joliet, Ill	32.56	1.50	.60	25.00	1.00	165,850.00

[a] If awarded this contract, will bid $0.15½ per cubic yard on class 1, excavation, under schedule 2.

SCHEDULE No. 2.—CANAL EXCAVATIONS AND EMBANKMENTS (INCLUDING EMBANKMENT AT DIVERSION DAM).

Bidder.	Excavation.				Overhaul (200,000 cubic yards).	Total.
	Class 1 (800,000 cubic yards).	Class 2 (1,000 cubic yards).	Class 3 (1,000 cubic yards).	Class 4 (1,000 cubic yards).		
Widell-Finley Co., Mankato, Minn	$0.129	$0.25	$0.56	$1.25	$0.01	$107,260
Knowlton & Bollen Construction Co., Fort Collins, Colo	.13¾	.35	.50	.95	.015	114,800
S. R. H. Robinson, St. Louis, Mo	.14	.38	.60	1.00	.01	115,980
W. C. Bradbury, Denver, Colo	.155	.40	.40	1.20	.015	129,000
Kilpatrick Bros. & Collins Construction Co, Beatrice, Nebr	.155	.45	.45	.85	.02	129,750
Henry Wyttenbach, Sturgis, S. Dak	.16	.32	.45	.90	.015	132,670
Daniel J. Burke, Alliance, Nebr	.15$\frac{15}{16}$	.38	.39	.89	.02	133,160
Orman & Crook Pueblo, Colo	.16	.30	.40	.85	.02	133,550
Faris-Kesl Construction Co., Boise, Idaho [a]	.16	.85	.95	1.25	.015	134,050
James Munn & Edward Hanschka, Deadwood, S. Dak	.17	.34	.45	.90	.015	140,690
Winters, Parsons & Boomer, Spokane, Wash	.17	.40	.45	.90	.015	140,750
Phalen & Shirley, Callahan Bros. & Katz, Omaha, Nebr	.18	.35	.45	.95	.015	148,750
Deeks & Deeks, St. Paul, Minn	.185	.60	.75	1.25	.015	153,600
Carroll Contracting Co., St. Louis, Mo	.19	.45	.70	1.50	.015	157,650
Bates & Rogers Construction Co., Chicago, Ill	.22	.50	.75	1.00	.03	184,250
Keltie Contracting Co., Joliet, Ill	.24	.50	.75	1.15	.02	198,400
Burrell Construction Co., Oakland, Cal	.35	.70	1.50	1.70	.04	291,900

[a] If awarded this contract, will bid $4.25 per cubic yard on concrete under schedule 1.

CEMENT.

Bids were requested April 10, 1905, at Washington, D. C., for furnishing cement for the diversion dam, the lowest ($2.15 per barrel, deliverd at Belle Fourche) being that of the Western Portland Cement Company, of Yankton, S. Dak. The cement has been carefully analyzed and tested, both by the cement experts of the Reclamation Service and in the field laboratory at Belle Fourche, and has shown good strength and quality. About 10,000 barrels are needed for work let.

RIGHT OF WAY.

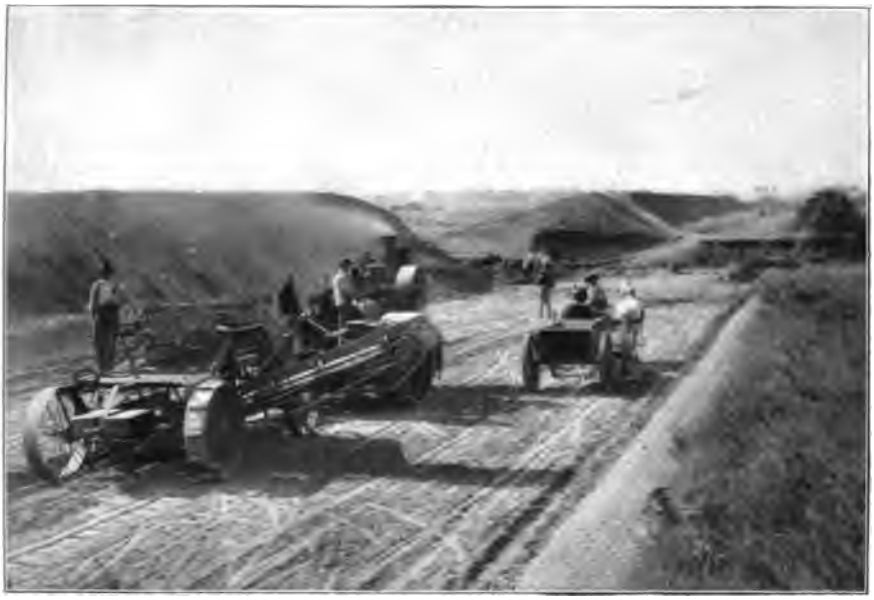
The right of way has all been secured for the supply canal, none of it being less than 200 feet wide. The land overflowed by the backwater from Crow Creek sluice and the diversion dam has all been secured, except 87 acres above the diversion dam and the relinquishment of damages caused by the occasional flooding of 48 acres.

The total acreage of land secured for the right of way and flooded area is 274.29 acres; $60 per acre was paid for cultivated and irrigated lands and $30 per acre for pasture lands, the average price being $40.12. This included all damages to the remaining land of the owners and is in lieu of the building of private bridges or fences.

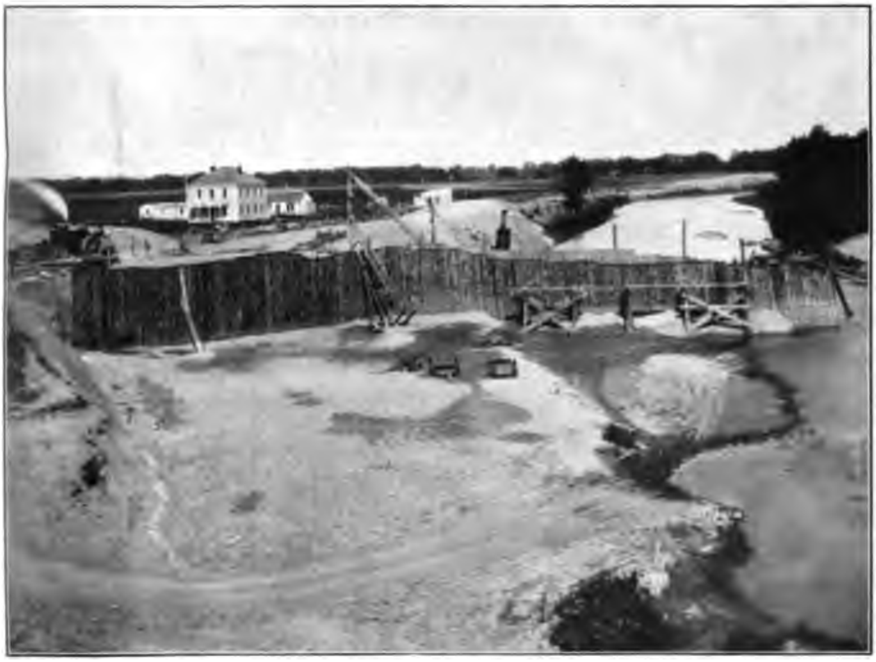
BELLE FOURCHE RESERVOIR.

LOCATION.

On account of the small summer flow and large spring flow of Belle Fourche River, the extent of reclamation in this valley must necessarily depend almost entirely on the available storage, and to store enough water at one time for all lands under the project was the aim of the engineers connected therewith. To accomplish this, it was finally decided to construct a



A. MAIN SUPPLY CANAL AT CROW CREEK SLOUGHS, BELLE FOURCHE PROJECT, SOUTH DAKOTA.



B. GENERAL VIEW OF HEADWORKS, MAIN SUPPLY CANAL, BELLE FOURCHE PROJECT, SOUTH DAKOTA.

large reservoir on Owl and Dry creeks, above the irrigable lands and at a point where water could be diverted into it from the Belle Fourche below Redwater River. The topography was found to be favorable, showing that a reservoir covering nearly 9,000 acres would be formed by a dam about 100 feet high across the valley of Owl Creek below the mouth of Dry Creek. This reservoir will be of sufficient capacity to give all the irrigable land under it 18 inches of stored water and allow for 25 per cent loss by seepage and evaporation.

Water will be run through the supply canal continuously throughout the year, except when ice interferes during the winter months. The supply will be equal to or greater than the demand except during the drought period, which comes from July 15 to September 15 in most years. About 80 per cent of the land submerged by the reservoir is Government land, the balance being purchased at $10 per acre.

CAPACITY.

Capacity of Belle Fourche reservoir.

Contour.	Area.	Capacity of section.	Total capacity.
	Acres.	*Acre-feet.*	*Acre-feet.*
2,920	583	....	....
2,925	875	3,644	3,644
2,930	1,240	5,287	8,931
2,935	1,640	7,199	16,130
2,940	2,084	9,309	25,439
2,945	3,031	12,786	38,225
2,950	3,852	17,207	55,432
2,955	4,640	21,232	76,664
2,960	5,573	25,535	102,199
2,965	6,349	29,806	132,005
2,970	7,174	33,806	165,811
2,970	8,010	37,959	203,770
2,985	8,888	42,246	246,016

DAM.

The board of consulting engineers met at Belle Fourche, S. Dak., June 26, and again at Denver, Colo., July 13, and approved the plans and specifications for the construction of the large earthen dam and appurtenances and about 17 miles of distributing canals.

The dam will be 6,500 feet long and 20 feet wide on top. The maximum height above the bed of Owl Creek will be 115 feet; the inside slope 2 to 1, protected from wash and ice action by 2 feet of screened gravel, rolled into place on the slope, on which will be placed concrete blocks 6 by 4 feet and 8 inches thick. These will be laid with open joints, the gravel layers acting as a drain under the blocks. The outer slope will be 2 to 1 and will be provided with concrete gutters for disposing of the rainfall. To prevent erosion, the slope will be fertilized and seeded with grass. The dam will be constructed in layers, each of which will be sprinkled and rolled with steam rollers to a great density. The material of which it will be built is heavy clay and gumbo, which weighs in some places 120 pounds per cubic foot. (See Pls. LV and LVI.)

The reservoir will be provided with two outlet conduits, surmounted with towers and gatehouses, of concrete and steel. These will deliver the water into the north and south canals for distribution.

The wasteway will consist of a semicircular concrete weir at the high-water line beyond the north end of the dam; this will deliver any flood waters coming down Owl Creek when the reservoir is full into a channel in a branch of Owl Creek below the dam. Drops will be constructed to prevent erosion of the waste channel between the reservoir and the creek.

Bids for the construction of the dam were opened October 26, and an abstract of those received is given below:

Bids on Belle Fourche dam, South Dakota.

Item No.	Description.	Amount.	Orman & Crook, Pueblo, Colo.		Widell-Finley Co., Mankato, Minn.		Callahan Bros. & Katz, Omaha, Nebr.		Empire Engineering Co., by L. W. Bates, New York City.	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
1	Preparing surface beneath embankment	31 acres	$8.25	$255.75	$10.00	$310.00	$7.50	$232.50	$97.00	$3,007.00
2	Earth excavation from cut-off trenches:									
	Class A	18,000 cubic yards	.30	5,400.00	.25	4,500.00	.25	4,500.00	.15	2,700.00
	Class B	4,000 cubic yards	1.25	5,000.00	.40	1,600.00	.75	3,000.00	.20	800.00
	Class C	2,000 cubic yards	3.00	6,000.00	.60	1,200.00	1.25	2,500.00	.23	460.00
3	Earth excavation for structures at dam	6,000 cubic yards	.50	3,000.00	.50	3,000.00	.25	1,500.00	.42	2,520.00
4	Earth excavation for dam embankment	1,580 000 cubic yards	.28	442,400.00	.365	576,700.00	.35	553,000.00	.325	513,500.00
5	Earth excavation for stripping borrow and gravel pits	35,000 cubic yards	.16	5,600.00	.18	6,300.00	.25	8,750.00	.33	11,550.00
6	Earth excavation, trimming dam embankment	30,000 cubic yards	.30	9,000.00	.25	7,500.00	.25	7,500.00	.41	12,300.00
7	Gravel for roadways and on slope of dam	22,000 cubic yards	3.75	82,500.00	1.40	30,800.00	1.75	38,500.00	2.65	58,300.00
8	Screened gravel under concrete	do	4.00	88,000.00	1.50	33,000.00	2.00	44,000.00	3.15	69,300.00
9	Soil dressing, seeding, and caring for embankment	15 acres	30.00	450.00	200.00	3,000.00	800.00	12,000.00	1,630.00	24,450.00
10	Round wooden piles in place	450	11.44	5,148.00	9.00	4,050.00	4.50	2,025.00	10.90	4,905.00
11	Grading:									
	Class A	230,000 cubic yards	.20	46,000.00	.199	45,770.00	.18	41,400.00	.20	46,000.00
	Class B	25,000 cubic yards	.42	10,500.00	.35	8,750.00	.40	10,000.00	.40	10,000.00
	Class C	1,000 cubic yards	1.05	1,050.00	1.00	1,000.00	1.00	1,000.00	.80	800.00
12	Overhaul	10,000 cubic yards	.02	200.00	.01	100.00	.02	200.00	.015	150.00
13	Preparing surface for canal embankment	1 acre	8.25	8.25	10.00	10.00	8.00	8.00	97.00	97.00
15	Concrete masonry:									
	Class A	15,000 cubic yards	7.00	105,000.00	6.70	100,500.00	9.50	142,500.00	8.50	127,500.00
	Class B	1,700 cubic yards	6.80	11,560.00	6.95	11,815.00	10.00	17,000.00	7.90	13,430.00
	Class C	1,850 cubic yards	6.50	12,025.00	6.75	12,487.50	12.50	23,125.00	7.90	14,615.00
	Class D	280 cubic yards	6.80	1,904.00	7.50	2,100.00	12.50	3,500.00	7.90	2,212.00
	Class F	3,100 cubic yards	6.80	21,080.00	10.00	31,000.00	10.00	31,000.00	8.30	25,730.00
16	Gravel, screened and washed	2,000 cubic yards	3.80	7,600.00	.25	500.00	2.00	4,000.00	3.40	6,800.00

17	3 sluice gates, 4 by 6 feet, and guides complete; 5 ball-bearing gate stands; 7 gate shafts, screws, and shaft supports complete; 2 plain gate stands.			3,575.00		3,500.00		6,000.00		6,800.00
18	4 sets cast-iron gates, guides, and stop-plank guides	16,000 pounds	.085	1,360.00	.08	1,280.00	.07	1,120.00	.23	3,680.00
19	45 sections stop planks, complete			990.00		1,000.00		814.00		1,100.00
20	2 gatehouses, complete			1,423.00		3,500.00		1,952.50		2,050.00
21	Structural steel	14,000 pounds	.07	980.00	.08	1,120.00	.05	700.00	.055	770.00
22	Timber in place	25,000 feet B. M	39.00	975.00	40.00	1,000.00	22.00	550.00	62.00	1,550.00
23	12-inch vitrified pipe	300 linear feet	.60	180.00	5.00	1,500.00	.70	210.00	1.20	360.00
	Total			879,164.25		898,892.50		962,587.00		967,436.00

LAND FLOODED.

Of the total area of the flooded land in the reservoir 640 acres are owned by the State of South Dakota, and by the constitution of the State can not be sold for less than $10 per acre, but will be secured at the minimum price; 960 acres are in private ownership, and most of this has been purchased or arranged for at a maximum cost of $10 per acre. The balance, about 7,200 acres, is Government land, and though there are a few filings pending on this area no homes are flooded out nor improvements damaged. There are several desert filings in this area, but no reclaimed lands.

BORINGS AND TEST PITS.

A number of open borrow pits were sunk to bed rock under the proposed dam, and it was found that the distance to shale under the body of the dam was 40 feet. No continuous gravel or water-bearing strata were encountered, and the base under the dam will therefore be impervious. All borrow pits at which earth or gravel is to be obtained were carefully investigated by open test wells and borings.

An examination and analysis of the earth to be used in the dam was made by Thomas H. Means, and his report showed only a small amount of soluble matter in the material from most of the borrow pits, but in two pits there was a large percentage of gypsum, and this material will not be used.

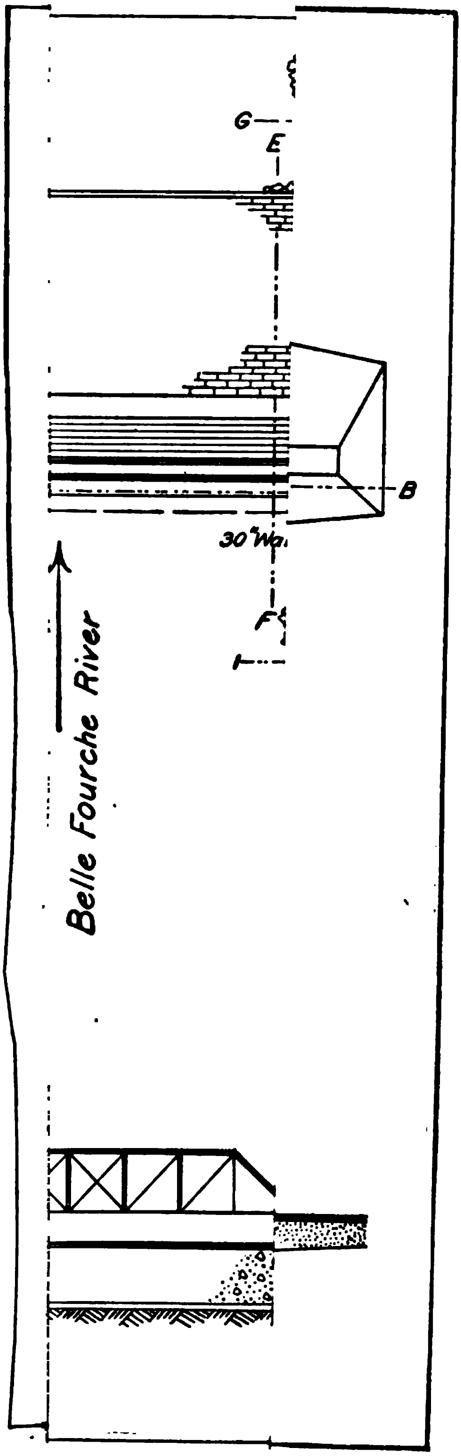
DISTRIBUTING SYSTEM.

The distributing system begins at the reservoir, as large bodies of irrigable land are located adjacent to the reservoir and extend to the east and southeast continuously for 25 miles. The north canal will irrigate lands north of the river and east of Owl Creek, and the south canal lands south of the river and between Owl Creek and the river on the north side.

NORTH CANAL.

The total amount of irrigable land under the north canal is 66,857 acres, of which 3,450 acres are subject to overflow from the creeks and river during spring floods. The canal is about 45 miles long and will be 30 feet wide on bottom and carry water 7 feet deep above the first lateral, decreasing in size as water is drawn out. There will be eight main laterals from the canal to irrigate lands located some distance from the canal line, besides the farm laterals to adjacent lands. Indian and Horse creeks will be crossed by concrete steel siphons.

Bids for the construction of the first division of this canal, which will carry the water to Indian Creek and irrigate all the land on the flats south of the creek, were opened October 26, 1905, as follows:



RCHE PROJECT, S

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Bids for north canal, Belle Fourche project, South Dakota.

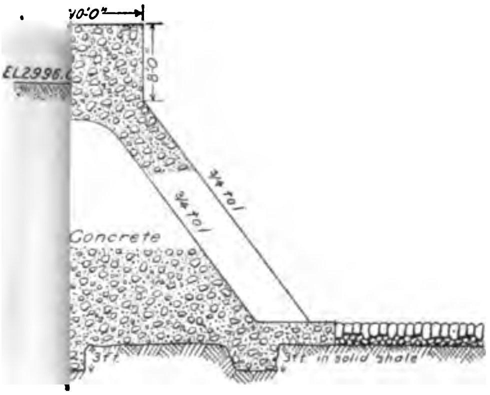
Item No.	Description.	Amount.	Orman & Crook, Pueblo, Colo.		Empire Engineering Co., by L. W. Bates, New York City.		Widell-Finley Co., Mankato, Minn.		Callahan Bros. & Katz, Omaha, Nebr.	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
5	Earth excavation for stripping borrow pits	2,000 cubic yards	$0.15	$300.00	$0.19	$380.00	$0.18	$360.00	$0.20	$400.00
7	Unscreened gravel for roadways	100 cubic yards	3.85	385.00	3.90	390.00	1.40	140.00	3.00	300.00
8	Screened gravel under concrete	100 cubic yards	3.85	385.00	4.40	440.00	1.50	150.00	3.50	350.00
11	Grading:									
	Class A	300,000 cubic yards	.165	54,450.00	.175	57,750.00	.18	59,400.00	.25	82,500.00
	Class B	10,000 cubic yards	.39	3,900.00	.40	4,000.00	.35	3,500.00	.40	4,000.00
	Class C	1,000 cubic yards	1.05	1,050.00	.80	800.00	1.00	1,000.00	1.00	1,000.00
12	Overhaul	150,000 cubic yards	.02	3,000.00	.0125	1,875.00	.0125	1,875.00	.01	1,500.00
13	Preparing surface for canal embankments	43 acres	8.25	354.75	80.00	3,440.00	10.00	430.00	10.00	430.00
14	Earth excavation from borrow pits	20,000 cubic yards	.165	3,300.00	.15	3,000.00	.18	3,600.00	.25	5,000.00
15	Concrete masonry, Class E	500 cubic yards	7.25	3,625.00	7.90	3,950.00	10.00	5,000.00	15.00	7,500.00
21	Structural steel	2,000 pounds	.07	140.00	.046	92.00	.09	180.00	.07	140.00
23	12-inch vitrified pipe	400 linear feet	.60	240.00	1.00	400.00	5.00	2,000.00	1.00	400.00
	Total			71,129.75		76,517.00		77,635.00		103,520.00

SOUTH CANAL.

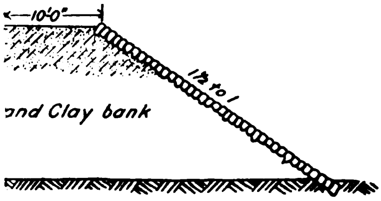
The south canal will water 28,240 acres of land, 7,595 acres of which are located between the reservoir and the river, the balance being on the south side of the river. The first section of the canal will be 18 feet wide on the bottom and carry 5 feet depth of water. No large laterals will be needed, as the land adjacent to the canal is nearly all irrigable direct from farm laterals. The amount of excavation is about 1,180,000 cubic yards.

Reenforced concrete conduits will be constructed across Belle Fourche River and Whitewood Creek. One tunnel 1,400 feet long will be necessary on account of high cut banks along the south side of the river below the crossing.

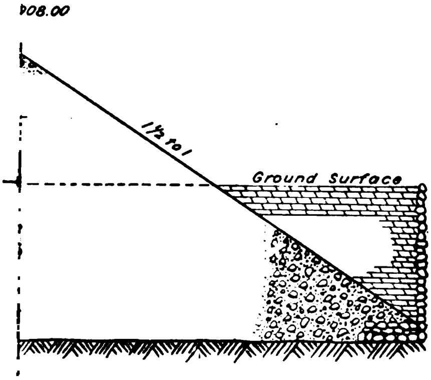
Bids were opened October 26 for the first section of this canal—that between the reservoir and the river. An abstract of the bids is given below:



SECTION AT D.C.



H DAM AT O.P.



Bids for south canal, Belle Fourche project, South Dakota.

Item No.	Description.	Amount.	Orman & Crook, Pueblo, Colo.		Empire Engineering Co., by L. W. Bates, New York City.		Widell-Finley Co., Mankato, Minn.		Callahan Bros. & Katz, Omaha, Nebr.	
			Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
5	Earth excavation for stripping borrow pits	4,000 cubic yards	$0.15	$600.00	$0.19	$760.00	$0.18	$720.00	$0.20	$800.00
7	Unscreened gravel for roadway	100 cubic yards	3.85	385.00	3.90	390.00	1.40	140.00	3.00	300.00
8	Screened gravel under concrete	100 cubic yards	3.85	385.00	4.40	440.00	1.50	150.00	3.50	350.00
11	Grading:									
	Class A	215,000 cubic yards	.165	35,475.00	.175	37,625.00	.19	40,850.00	.25	53,750.00
	Class B	14,000 cubic yards	.39	5,460.00	.40	5,600.00	.35	4,900.00	.40	5,600.00
	Class C	1,000 cubic yards	.99	990.00	.80	800.00	1.00	1,000.00	1.00	1,000.00
12	Overhaul	130,000 cubic yards	.02	2,600.00	.0125	1,625.00	.0125	1,625.00	.01	1,300.00
13	Preparing surface under canal embankment	24 acres	8.25	198.00	80.00	1,920.00	10.00	240.00	10.00	240.00
14	Earth excavation from borrow pits	25,000 cubic yards	.165	4,125.00	.15	3,750.00	.18	4,500.00	.25	6,250.00
15	Concrete masonry, class E	350 cubic yards	7.25	2,537.50	7.90	2,765.00	10.00	3,500.00	15.00	5,250.00
21	Structural steel	1,000 pounds	.07	70.00	.046	46.00	.09	90.00	.05	50.00
23	12-inch vitrified pipe	300 linear feet	.60	180.00	1.00	300.00	5.00	1,500.00	1.00	300.00
	Total			53,005.50		56,021.00		59,215.00		75,190.00

LATERAL SYSTEM.

Laterals will be constructed from the main canals to each farm entry. An accurate estimate of cost can not be made until they are located on the ground.

Lateral No. 1 will water land located south of the reservoir and above its outlet canals, and will head from the supply canal just before it enters the reservoir. The area under this lateral is 2,953 acres. It is known as the Johnston lateral.

Lateral No. 2 will water land located on the divide between Horse Creek, below the mouth of Indian Creek, and the river. It will serve 8,146 acres. It is known as the Wilson lateral.

Lateral No. 3 will water land located on the east side of the divide between Horse Creek and Dry Creek and will serve 9,011 acres. This is known as the Town lateral.

Lateral No. 4 will water land on the west side of the same divide along Horse Creek, amounting to 1,996 acres.

Lateral No. 5 will serve 9,832 acres between Dry Creek and Deer Creek. Being on the divide it will irrigate both ways.

Lateral No. 6 will water land between Deer Creek and the high divide near Willow Creek, serving 2,669 acres.

Lateral No. 7 will serve 448 acres located between the canal line and Deer Creek. This is a short lateral.

Lateral No. 8 will water 1,366 acres of land along Willow Creek above Willow Creek Pass.

Lateral No. 9 will cross Willow Creek at the pass through a siphon and will serve 6,134 acres on the east side of Willow Creek, below the pass.

The above laterals will require the excavation of 850,000 cubic yards of earth and the construction of about 2 miles of siphons of various sizes and of numerous lateral gates and measuring weirs. They will carry water to all the lands under the north canal, except those directly adjacent to the main canal lines, and will deliver the water to sublaterals running to the farm entries. Laterals and sublaterals will be provided with conduits of sewer pipe fitted with regulating gates of iron and concrete weirs for the measurement of water, so that each farm entry can get its proportionate amount, according to the acreage under it.

TELEPHONE SYSTEM.

In the operation of a large irrigation system quick intercommunication is necessary for all parts of the work. Each ditch rider on each section of canal or lateral must receive his instructions daily and must also be able to report daily to the superintendent the amount of water he needs for the coming day, also any breaks in the canals or damages from storm. For this work a telephone system is essential throughout the district, and as it is also very convenient during construction work it was decided to build a permanent line at the start, connecting the head of the canal and the reservoir with the town of Belle Fourche, this line to be afterwards extended along the distributing canals as needed. The line built is 16 miles long, of double-circuit copper wire, with long-distance telephones.

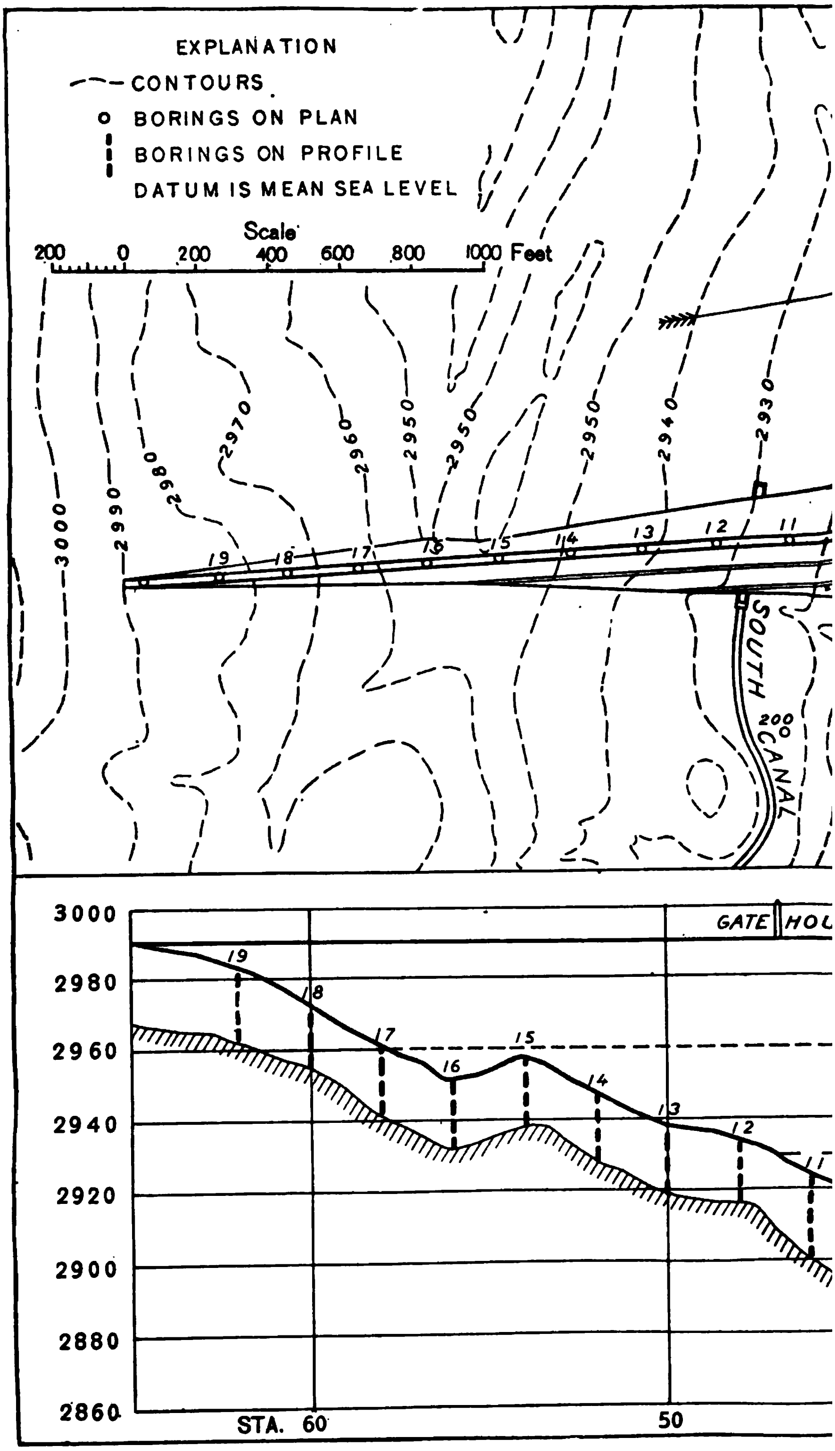
Bids for its construction were opened June 26, the contract was awarded July 20, and the line was completed September 12. A summary of the bids follows:

Bids received for telephone system, Belle Fourche project, South Dakota.

Bidder.	Cost per mile.	Cost of instruments.	Total estimated cost.	Time of completion.
W. H. Crumb & Co., Chicago, Ill.	$254.50	[a] $80.00	$4,152.00	August 15.
Henry Wittenbach, Sturgis, S. Dak.	303.60	105.00	4,962.60	Sixty days.
Robert W. Day, Rapid City, S. Dak.	300.00	400.00	5,200.00	Forty days.
John Musselman, Deadwood, S. Dak.[b]	349.00	126.00	5,710.00	September 1.

[a] $380 if not awarded section 1.

[b] Specifications not attached to bid.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IRRIGABLE LANDS.

The irrigable lands under the project were mapped during the summer of 1904, and a complete irrigation and topographic map has since been prepared, showing the lands, together with the reservoir, main canals, and main laterals, on a scale of 2 inches to the mile, with 10-foot contours. The plane-table mapping was on a scale of 1,000 feet to the inch, with 5-foot contours.

The lands are located in Tps. 7, 8, 9, and 10 N., Rs. 3, 4, 5, 6, and 7 E., Black Hills meridian, in Butte and Meade counties, S. Dak. They include the valleys of Owl, Indian Horse, Dry, and Willow creeks on the north side of the river and the lower valleys of Whitewood and Ninemile creeks on the south side. Some of the land along these creek bottoms is overflowed during the spring floods, and in years when the floods occur at the proper time the land produces an abundance of hay, known throughout this locality as Indian Creek hay, which sells at a high price.

CLASSIFICATION AND SOIL.

The land has been divided for convenience into four classes. The first class is first-class irrigable land in every respect, having a slope of less than 5 per cent. The second class is land overflowed occasionally by creeks or river, and, if cleared, produces good crops of hay in most years without irrigation. The third class is land that has a slope of between 5 and 10 per cent, and is therefore not as desirable as the first class, or it is land that would require a more expensive sublateral system, large dikes, flumes, or siphons to get water to it. It will in time be irrigated, but not until after all the first-class land is taken and the country further developed. The fourth-class land is nonirrigable, on account of being too high, too rough, or in creek or river beds.

The soil is free from gravel or rocks and is all good. The north side, being clay soil, will be more difficult to subdue, but after it is in cultivation a few years will be the best producer. The south-side soil is generally a sandy loam and easy to work, but will require more water than the clay soil. Great care will have to be taken by the farmers to avoid using an excess of water on the land.

Very little alkali is found on the surface, and there is no indication whatever of black alkali. Soluble salts form an extremely low percentage of all soils.

Drainage ditches will be needed for part of Indian Creek flat, where the surface slope is extremely slight and there is no subdrainage.

Location and classification of irrigable lands under Belle Fourche project, South Dakota.

Location.	Classification.		
	First class.	Overflow.	Third class.
	Acres.	*Acres.*	*Acres.*
T. 7 N., R. 5 E	857.0		
T. 7 N., R. 6 E	772.0		3.0
T. 7 N., R. 7 E	3,333.0		167.5
T. 8 N., R. 3 E	723.0		32.0
T. 8 N., R. 4 E	2,906.5		250.0
T. 8 N., R. 5 E	8,442.0	127.5	176.5
T. 8 N., R. 6 E	14,267.5	592.5	1,491.0
T. 8 N., R. 7 E	10,462.0	359.5	1,134.5
T. 9 N., R. 2 E	50.0		
T. 9 N., R. 3 E	827.5		39.5
T. 9 N., R. 4 E	11,953.0	483.0	443.5
T. 9 N., R. 5 E	8,383.0	1,248.5	813.5
T. 9 N., R. 6 E	14,109.0	88.0	2,260.5
T. 9 N., R. 7 E	3,146.0	412.0	374.0
T. 10 N., R. 3 E	556.5	69.0	329.5
T. 10 N., R. 4 E	5,068.5	240.5	267.0
T. 10 N., R. 5 E	669.5		23.0
T. 10 N., R. 6 E	246.0	22.0	16.0
Total	86,772.0	3,642.5	7,821.0

Grand total, 98,235 acres.

CROPS.

Hay, both native and alfalfa, will always be the staple crop, as the demand for winter feed for the thousands of head of cattle which graze the prairies during the summer north and east for a hundred miles from this location is becoming greater every year, the town of Belle Fourche being one of the greatest beef-cattle shipping points in the United States. There are indications that this area will also be used considerably for producing beet sugar, as manufacturers have looked over the land and signified their intention of locating factories as soon as needed. Small grains, potatoes, and hardy fruits will also be profitably raised.

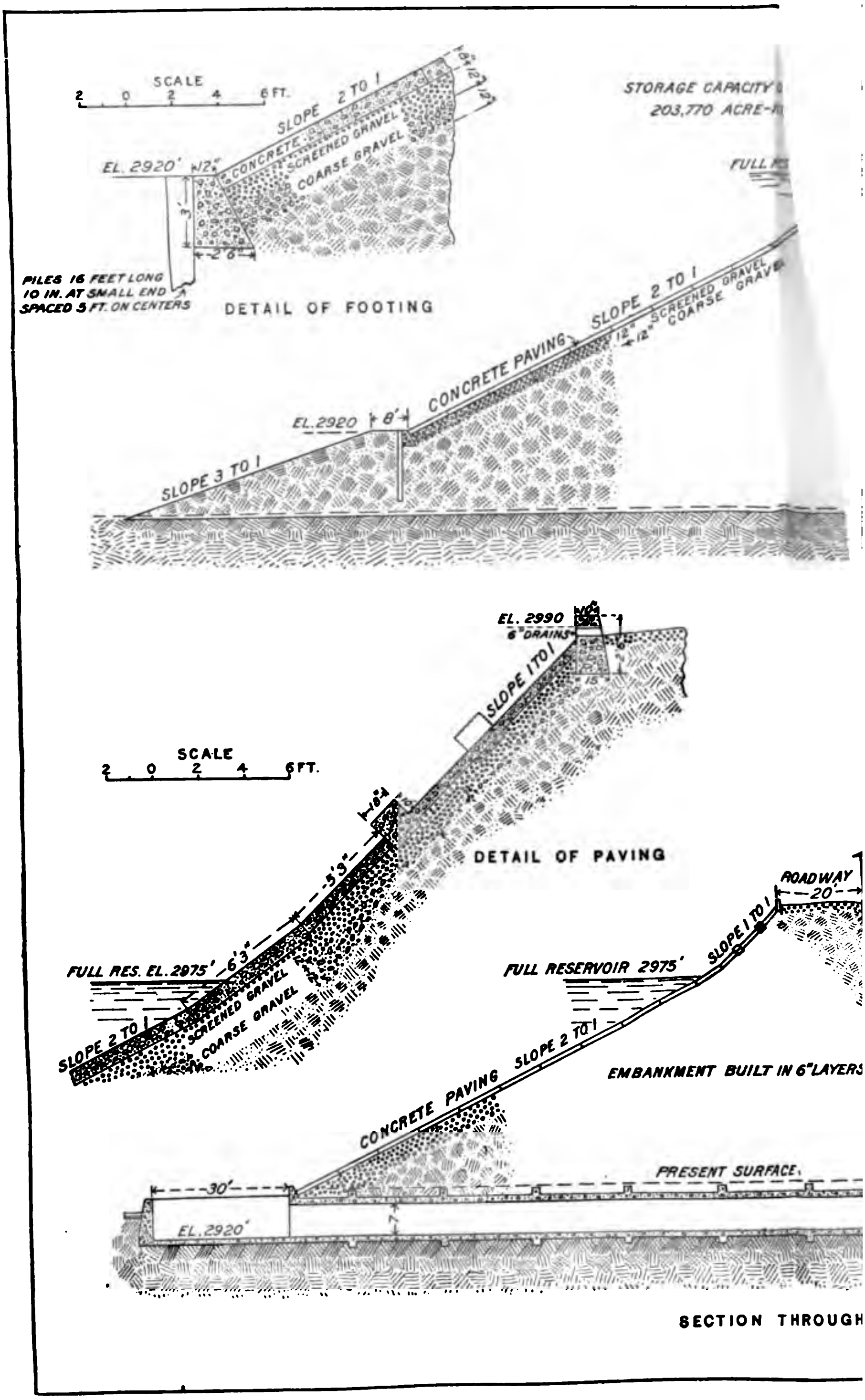
OWNERSHIP.

Ownership of irrigable lands at segregation, Belle Fourche project, South Dakota.

Ownership.	First class.	Second class.	Third class.
	Acres.	*Acres.*	*Acres.*
Government	37,873.5	172.5	4,894.0
State	4,425.0	263.5	507.0
Private	36,024.0	2,901.0	1,568.5
Title pending	8,449.5	305.5	851.5
Total	86,772.0	3,642.5	7,821.0

Grand total, 98,235 acres.

Land headed "title pending" is that held in desert or homestead entries at the time of segregation, and much of it has been abandoned and recommended for cancellation, but no final action has yet been taken by the General Land Office.



DETAIL OF FOOTING

DETAIL OF PAVING

SECTION THROUGH

Of the land in private holdings, with the exception of 7,941 acres most of which are owned in tracts of over 160 acres by individuals who refuse to sell it in small holdings at this time, all is signed for water, and the owners thereof have become members of the Belle Fourche Valley Water Users' Association.

State lands will be sold in farm units of 80 acres of irrigable land at from $10 per acre up.

Land held in private ownership not signed up at close of books of the association.

	Acres.
First class	6,534
Second class	803
Third class	604
Total	7,941

Land in which title is pending, not signed up.

Land held in desert entries, none of which has been reclaimed, and in homestead entries, most of which has been reported for cancellation, is as follows:

	Acres.
First class	3,956
Second class	92
Third class	401
Total	4,449

FARM UNITS.

The farm unit on Government and State land will be 80 acres of irrigable land, except within 2 miles of town sites, where the limit is reduced to 40 acres. The farm-unit maps will be filed with the United States land office during the coming winter. Farm units on private lands can not exceed 160 acres of irrigated land.

BUILDINGS AND QUARTERS.

An office building containing eight rooms, bathroom, cellar, etc., was constructed at the head of the inlet canal, about 1½ miles from Belle Fourche, S. Dak. This building can be used as a residence for the gate keeper or superintendent after the construction is completed. It cost complete $2,559.02, and is used as State headquarters for all reclamation work in South Dakota. Temporary quarters, consisting of sleeping houses, kitchen, and dining room for men, and small barn for teams, were constructed near the work on the inlet canal, at a cost of $1,117.16. An artesian well 627 feet deep and piped with 2-inch pipe was drilled at the office building to furnish water to workmen and contractors. The cost of this well was $605.32. An abundant flow was obtained, which is available for contractors' and neighborhood use.

Engineers' quarters, consisting of two sleeping houses, a cook house and dining room and a barn, were also constructed at the location of the Belle Fourche reservoir dam, 12 miles northeast of the town of Belle Fourche, at a cost of $2,001.25. A house for the use of the resident engineer, to cost $1,000, and a small office building, to cost $800, are about completed. As there was no fit water for domestic use near this locality, it was necessary to sink an artesian well. The distance to water was 1,390 feet, and the well was piped with 2 and 3 inch pipe. It flows a small stream (about 1,500 gallons a day) of good water continuously. The cost was $1,785.27. This water is piped to all the houses of the Reclamation Service here.

WATER SUPPLY.

RAINFALL.

Belle Fourche River collects water from a drainage area of 4,300 square miles in western South Dakota and eastern Wyoming. During 1905 the rainfall has been far above normal at the project location, but was not so great on the upper drainage area of the river. The river did not have any large floods during the year, but ran a steady stream throughout the season.

The small creeks, such as Crow, Owl, and Indian, carried considerable water which would have been available for storage, as they were in flood at numerous times when the river was flowing less than the canal capacity. These are not taken into account, but will go far toward making up for evaporation.

Monthly rainfall at Belle Fourche, S. Dak.

	1904.	1905.
	Inches.	*Inches.*
May	1.94	6.42
June	4.68	4.16
July	.42	5.51
August	2.32	2.08
September	.23	.97

Annual rainfall of Black Hills.

[By United States Weather Bureau.]

Year.	Rapid.	Fort Meade.	Farmingdale.	Ashcroft.	Oelrichs.	Spearfish.	Silver City.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1881	....	15.06	....	....	....	....	....
1882	....	19.32	....	....	....	....	....
1883	....	27.05	....	....	....	....	....
1884	....	22.97	....	....	....	....	....
1885	....	13.25	....	....	....	....	....
1886	....	13.51	....	....	....	....	....
1887	....	18.93	....	....	....	....	....
1888	22.11	20.00	....	....	....	....	....
1889	17.98	18.00	....	....	....	21.87	....
1890	13.01	16.23	....	....	....	20.73	....
1891	16.87	21.79	....	....	22.05	26.32	....
1892	19.63	24.00	....	....	33.88	26.82	....
1893	9.58	19.12	....	13.64	16.82	22.85	....
1894	14.04	16.78	....	15.12	19.31	28.69	....
1895	16.39	....	10.82	13.17	....	....	22.80
1896	14.76	17.61	....	19.46	17.57	....	....
1897	13.36	16.62	....	10.50	....	18.92	....
1898	10.97	23.15	10.31	15.24	....	11.89	....
1899	15.64	20.37	15.54	14.41	20.65	17.54	23.11
1900	14.66	13.92	12.83	12.92	12.93	17.73	....
1901	22.59	23.28	....	10.39	24.34	19.14	19.85
1902	18.51	22.19	14.75	16.00	19.79	....	17.26
1903	21.28	23.89	17.12	12.21	18.57	29.41	27.01
1904	16.40	18.97	16.22	10.42	12.28	24.40	....
Normal	16.34	19.38	13.94	13.62	19.83	22.02	22.05

RUN-OFF OF BELLE FOURCHE RIVER.

The following tables give the estimated flow of Belle Fourche River at the diversion dam for 1903, 1904, and 1905. These estimates have been obtained by adding the mean monthly discharge of Redwater River at Belle Fourche to that of Belle Fourche River at Belle Fourche. These two stations are just above the confluence of the two streams, and about 1½ miles above the diversion dam.

Estimated monthly discharge of Belle Fourche River at diversion dam.

[Drainage area, 4,265 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1903.						
June	385	85	184	10,955	0.043	0.048
July	1,086	70	201	12,343	.047	.054
August	4,218	148	913	56,016	.214	.247
September	4,755	177	915	54,363	.215	.240
October	201	166	177	10,870	.042	.048
Period	4,755	70	478	144,547	.112	.637
1904.						
March 10–31	2,082	419	1,070	46,601	.251	.205
April	705	334	521	30,957	.122	.136
May	1,903	238	532	32,684	.125	.144
June	13,814	410	2,667	158,432	.625	.697
July	671	140	338	20,770	.079	.091
August	258	85	126	7,740	.030	.035
September	376	217	248	14,717	.058	.065
October	1,259	245	346	21,280	.081	.093
November	314	272	294	17,490	.069	.077
December	432	279	329	20,230	.077	.089
Period	13,814	85	647	370,901	.152	1.632
1905.						
March 5–31	585	247	318	17,030	.075	.075
April	324	265	288	17,140	.068	.076
May	1,585	259	762	46,850	.179	.206
June	1,303	261	603	35,880	.141	.157
July	2,510	424	1,044	64,200	.245	.282
August	3,220	233	789	48,510	.185	.213
September	290	225	255	15,170	.060	.067
Period	3,220	225	588	244,770	.138	1.076

Estimated amount of water that could have been stored from Belle Fourche River by system as planned.

Month.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1903.				
June	385	85	184	10,936
July	1,086	70	201	12,340
August	1,635	148	657	40,387
September	1,635	177	704	41,933
October	201	166	177	10,870
Period	1,635	70	385	116,253
1904.				
March 10-31	1,635	419	985	43,117
April	705	334	521	30,957
May	1,635	238	521	32,019
June	1,635	410	1,235	73,373
July	671	140	338	20,770
August	258	85	126	7,740
September	376	217	248	14,717
October	1,259	245	346	21,280
November	314	272	294	17,490
December	432	279	329	20,230
Period	1,635	85	494	281,700
1905.				
March 5-31	585	247	318	17,030
April	324	265	288	17,140
May	1,585	259	762	46,850
June	1,303	261	603	35,880
July	1,635	424	980	60,260
August	1,635	233	700	43,040
September	290	225	255	15,170
Period	1,635	225	558	235,400

WATER USERS' ASSOCIATION.

An association of owners of private lands under the project was organized in June, 1904, and incorporated under the laws of the State of South Dakota. It is known as the Belle Fourche Valley Water Users' Association, and represents nearly all the private landowners in the district. The following officers were elected in November, 1904, and served during the present year: President, Walter Hamilton; vice-president, George Maass; secretary, W. A. McMichael; treasurer, W. B. Penfold; attorney, Wesley Stuart. Directors, Walter Hamilton, C. P. Greenley, A. Giles, Peter Edwards, George Maass, John P. Wilson, F. A. Gaskill, Nis Sorensen, and John Glover.

TOWN SITE.

The S. ½ sec. 20 and the N. ½ sec. 29, T. 9 N., R. 6 E., have been reserved for a town site, as it is thought this will be the center of a large farming community after the system is in operation. The lots will be appraised and sold at public auction. The site will be surveyed and town lots plotted and thrown open for sale during the summer of 1906. It is expected that the proceeds of the sale of these lots will be available for municipal improvements, schoolhouses, parks, streets, etc.

The NE. ¼ sec. 24, T. 9 N., R. 5 E., has been selected by the United States Department of Agriculture for a demonstration farm, on which experiments will be conducted by the most approved methods.

This farm will be but 2 miles from the Government town site and will prove a valuable educator for those farmers who are not experienced in irrigation farming.

WATER RIGHT FOR PROJECT.

There are at this time below the head of the supply canal no canals or power plants which use the water of Belle Fourche River. Hence the Belle Fourche project is entitled to any and all water in the river at the head of the supply canal, both for direct irrigation and for storage, and the same has been appropriated for its use. There is considerable irrigation done along Redwater River and Spearfish Creek, which flow into the Belle Fourche above the head of the project, but no extension of this present use can be made to the detriment of the project, and therefore the total estimated present flow is available for irrigation and storage.

EXPENDITURES.

The expenditures on the Belle Fourche project to September 30, 1905, were as follows:

Expenditures on Belle Fourche project to September 30, 1905.

Diversion dam, construction, S. R. H. Robinson	$17,010.38
Main canal, excavation, Widell-Finley	20,822.85
Buildings, force account	8,000.00
Rights of way	4,000.00
Preliminary examination	11,000.00
Surveys	30,000.00
Engineering and supervision	14,000.00
Administration	13,099.66
Total	117,932.89

CHEYENNE RIVER RECONNAISSANCE.

At the request, made during the summer of 1904, of citizens living on W. G. flats southeast of Hot Springs, S. Dak., a reconnaissance was made of the upper waters of Cheyenne River and its branches for possible reservoir sites. None were found on the main river that could be constructed at a cost permissible by the amount of land to be reclaimed. Possible sites were located on Hat Creek and Beaver Creek, but as nothing was known of the flow of these creeks, gaging stations were established, so that a careful study of the water supply of each could be made.

Cheyenne River is torrential, but is generally dry at the time it is needed for irrigation, rendering storage necessary. The report of the available water supply in branches where storage can be obtained will be published in the progress report of stream measurements of the Geological Survey for 1905. About 40,000 acres of first-class land are situated along the Cheyenne, but even if the water supply proves satisfactory the cost of reclamation would be high on account of the land being so scattered and requiring long and expensive canals. The land is mostly in private ownership.

LITTLE MISSOURI RIVER RECONNAISSANCE.

During the summer of 1904 a possible storage system by which the flood waters of Little Missouri River could be utilized for irrigation was surveyed near Alzada, Mont.

Gaging stations were established on the river near the reservoir site and at Camp Crook, S. Dak., near the irrigable land, and a careful record of the available flow was kept daily.

The land is mostly owned by the Government, and possibly 40,000 acres may be reclaimed as railroad facilities come within reach of this territory.

STREAM MEASUREMENTS.

A careful record is being made of the run-off of White River south of the hills and Owl and Grand rivers to the north, and the results studied. Further surveys will be made as opportunity affords and railroad construction opens up the country for settlement.

OPERATIONS IN UTAH.

By George L. Swendsen.

During the last year some very important conclusions have been reached relative to the reclamation projects for Utah. By the end of the field season of 1904 the Utah Lake and Bear Lake projects were very thoroughly understood so far as engineering problems were concerned, and these results, together with the review of water-right matters and other complicating elements, led to the conclusion that neither could be put under construction for some years to come. A brief statement of the results and progress on these two valuable projects follows.

The consideration of Weber River, another of the large and valuable water resources of the State, was barely begun when conflicting interests indicated the advisability of discontinuing the work there.

The Strawberry Valley project has proved on examination to be the most feasible and least complicated of all projects so far considered, and it is now the foremost project in the State and the only one on which early construction is contemplated.

UTAH LAKE PROJECT.

Results of examination of this project are given in the First Annual Report of the Reclamation Service, pages 279 to 282, the Second Annual Report, pages 451 to 475, and in the Third Annual Report (second edition), pages 494 to 508. Examinations subsequent to the publication of Third Annual Report were limited to securing details, and no important conclusions were modified thereby.

In March, 1905, a final report on the project was considered by a board of engineers, and it was decided that the investigations on the project should be discontinued for the present. When all problems connected with the project were considered, it was doubtful if it was feasible under the requirements of the Reclamation Service. The great area of the lake makes it an extremely inefficient reservoir, as about two-thirds of all water reaching the lake is lost by evaporation. The use of the flood waters of streams tributary to the lake for irrigation is increasing from year to year, and when such beneficial use is considered it would seem that a court might decide such claim to supersede the right to have the waters flow into the lake to supply the evaporation from the reservoir. In the entire history of the project it has not appeared that there was any substantial effort on the part of the owners of existing canals to form a water users' association to further the project.

It is probable that the great value of the additional water that the lake can supply will insure the necessary works for its utilization in the near future. One unit has been added to the Jordan pumping plant, increasing its capacity to 500 second-feet, and two substantial enterprises have recently been started to pump water from the lake to the high lands along the Jordan. One of these will cover about 15,000 acres, and if both are developed the lake supply will be exhausted.

In connection with the additional draft that is being made on the lake it is interesting to note that the fluctuations of level are following very closely those determined by the hydrographic investigations and computations tabulated in the Third Annual Report.

BEAR LAKE PROJECT.

The preliminary examination of this project was concluded in the fall of 1904, and a detailed report of the observed conditions is given in the Third Annual Report of the Reclamation Service (second edition), pages 514–544.

During the winter of 1904 all matters relative to the project were very carefully considered, and a general outline of the possibilities was definitely determined. The plan for storage in the lake is simple, but the canals will need to be large. After careful study of all conditions relative to distributing canals it appears most feasible to have the main diversion made by means of a dam about 200 feet high in the narrow canyon of Bear River about 12 miles north of the Utah-Idaho line. Thence the water would be taken by a tunnel about 3 miles long, opening into the north end of Cache Valley. At the outlet of this tunnel it would be carried in two main canals, one running southward to cover the valuable Cub River bench of 20,000 acres, and the other westward and southward along the western side of Cache Valley, extending about 20 miles into the State of Utah, and ultimately reaching about 125,000 acres of land. A branch of this latter main canal would also extend northward to Marsh Valley to irrigate about 15,000 acres. The total area covered (160,000 acres) is about equally divided between the States of Utah and Idaho.

The Bancroft Valley, the most northerly area heretofore considered in connection with this project, is not included in the present plan. Developments are now under way to reclaim the best portions of that section by an enlargement and extension of the Last Chance canal. This is a farmers' cooperative canal, and will in the end meet the requirements of that section in the cheapest and most satisfactory manner.

If this plan is carried into effect, a great deal of very expensive construction would be necessary before any benefits would result.

For some years past two different companies have been developing plans for securing water through the utilization of Bear Lake, and while the construction accomplished is not extensive and the plans for future developments are not made public, in either case the claims of these companies are matters to be considered with reference to the water filings and water rights, at least, if not in relation to the reservoir. Both of these companies are largely interested in power development, and should their claims be recognized their plans may seriously interfere with the use of the water for irrigation.

Considerable water from Bear River is now used for irrigation in Wyoming and a much larger amount in Utah and Idaho. Claims under the Utah and Idaho canals are conflicting, and in some cases extravagant. The canals in most cases are being improved and the irrigated area extended, and the adjudication of the vested rights would involve many difficult problems and necessarily require a number of years.

STRAWBERRY VALLEY PROJECT.

The feasibility of developing a small project to utilize the waters of Strawberry River is suggested in the Third Annual Report (second edition), pages 513 to 514, as a result of the reconnaissance for the storage and diversion of several of the streams in the Uinta Mountains.

About January 1, 1905, a very large body of the farmers of southern Utah County initiated further inquiry into the matter by a petition to the Chief Engineer. The results of the investigations are outlined below.

IRRIGABLE LANDS.

Investigation has shown that the project will include about 50,000 acres in the southern part of Utah County and to the south and southeast of Utah Lake. These lands are all in private ownership and partially irrigated from the streams tributary to Utah Lake. Where the water supply is such as to secure the most profitable crops the lands are very valuable, but existing canals were built many years ago, and because of the comparatively difficult construction necessary to reach the bench lands cultivation has been confined largely to the low valley lands.

The project contemplates the development of these arid bench lands and, by extension and enlargement of existing canals, the more complete irrigation of the entire area.

WATER SUPPLY.

The streams now available for water supply to the tract, with the discharge during the irrigation months, are represented in the following table:

Monthly discharge, in acre-feet, of Spanish Fork, Hobble, and Payson Creeks, Utah.

Stream.	Year.	May.	June.	July.	August	September.
Spanish Fork	1901	16,663	7,914	4,735	6,087	4,463
	1903	13,958	12,972	4,858	3,951	3,094
	1904	19,860	8,985	5,077	4,181	3,749
	1905	17,094	10,000	4,500	....	....
	Mean.	16,900	10,000	4,800	4,700	3,800
Hobble Creek	1904	8,200	2,700	2,000	1,200	1,000
	1905	5,100	2,970	1,600	....	....
	Mean.	6,600	2,800	1,800	1,200	1,000
Payson Creek	Mean.	1,200	600	600	600	600
		24,700	13,400	7,200	6,500	5,400

Grand total, 57,200 acre-feet.

The discharge as shown for the month of May is sufficient for the irrigation of the entire area during that month, but the great decrease in the following months limits the area that is profitably cultivated. No other streams within the great basin are available to supply the deficiency, and it is proposed to store the entire flow of Strawberry River and construct such works as will add this supply to the normal flow available for irrigation, and thus complete the proper irrigation of the entire tract.

In the following table are given the results of measurements on Strawberry River for 1904 and 1905:

Discharge, in acre-feet, of Strawberry River.

Month.	1904.	1905.	Mean.
January	1,660	1,600	1,630
February	1,553	1,500	1,527
March	1,660	3,100	2,380
April	5,771	9,800	7,785
May	22,873	17,800	20,336
June	8,627	8,900	8,763
July	3,566	3,300	3,433
August	2,459	2,400	2,430
September	1,725	[a]1,700	1,712
October	1,660	[a]1,600	1,630
November	1,606	[a]1,600	1,603
December	1,660	[a]1,600	1,630
Total	54,820	54,900	54,859

[a] Estimated.

A comparison of this record with that of Provo River for the same years shows that the run-off is a little greater than one-fifth that of the Provo. By utilizing the complete record of the Provo since 1890 and applying this factor the following table is prepared to show the probable run-off of the Strawberry during that period:

Probable run-off of Strawberry River, 1890–1904.

	Acre-feet.
1890	83,000
1891	73,000
1892	68,000
1893	77,000
1895	61,000
1897	83,000
1898	58,000
1901	52,540
1903	45,900
1904	54,800
Mean	65,600

The drainage area is 200 square miles, all above the 7,500-foot elevation, and includes some of the highest sections of the Uinta Range.

In consideration of these results it seems safe to assume that an annual supply of 50,000 acre-feet can be depended on by the storage of the flow of this stream. It is probable that half of the stored water will be used in July or August, as these are the months when the greatest acreage of most valuable crops will be served.

STORAGE CAPACITY.

The storage of the Strawberry can be accomplished by a very simple dam, with maximum height of 45 feet, affording a storage capacity of 100,000 acre-feet. A loose-rock structure with concrete core wall and backed with earth is contemplated. Borings at the dam site are now in progress. An adequate spillway site is available some distance from the dam, the discharge from the spillway to be into Indian Creek.

TUNNEL.

From the reservoir the water will be drawn through a tunnel 19,500 feet long, terminating in the head of Diamond Creek, a branch of Spanish Fork. This tunnel is the most expensive feature of the project and very careful surveys and examinations have been made to determine conditions as accurately as possible.

At the east portal the ascent of the mountain is quite gentle and in the first mile the ground has been tested to tunnel grade with a diamond drill. The material is found to be Tertiary sandstone and sandstone shales, with the sandstone predominating. The cores show these materials to be disposed in thin layers and chemical reactions indicate the presence of considerable lime. In each of the deep test holes an artesian flow of water was developed some distance above the tunnel grade and extensive pumping will be necessary in the east headings of the tunnel. On the west or Diamond Creek slope of the mountain there is one large bed of shale and sandstone outcropping very prominently, which at the tunnel line will be about 3,000 feet thick. This will be encountered at about 15,000 feet from the east portal and may require some permanent timbering in construction. Elsewhere it is hardly probable that anything but temporary timbers will be necessary. The tunnel can be given a maximum grade without materially adding to the length, and thus the section may be a minimum.

In order to develop electric power for use in constructing the tunnel the three following plans are under consideration: 1. A steam plant at the west portal, utilizing wood for fuel. 2. A steam plant at the nearest railroad point, utilizing coal for fuel. 3. A water-power plant on Spanish Fork.

DISTRIBUTING SYSTEM.

Existing canal systems are not located or constructed in the most satisfactory manner, but the discrepancy is not so great as to justify the abandonment of these systems and the construction of entirely new ones. By the rectification, extension, and enlargement of these canals fully 35,000 acres of the tract can be reached, and the results of inquiry indicate that only one new system will be required. It is expected that this one new canal will supply all the valuable highlands that can be profitably included in the project.

WATER USERS' ASSOCIATION.

When the project was first considered it was recognized that a unification of all the water interests of Spanish Fork Valley would be necessary for the proper manipulation of a comprehensive and successful system to utilize the additional water supply. The water rights of the valley are among the oldest in the State of Utah and it became a matter of great concern whether all these interests could be merged into one association including the water supply to be developed.

An association was formed following closely the forms of articles and by-laws of some other projects in the reclamation work, and stock subscription began with the provision that each subscriber take stock covering his entire irrigable area whether entirely without water or partially or entirely supplied from present available sources. In other words, his lands and existing water rights were to be merged into the association.

Of course the surrender of old water rights was a serious matter and really the only question in the organization that caused any apprehension. Finally, in order to secure entire unity of effort and to prevent possibility of question in any case, the association entered into the following agreement with each subscriber owning water in Spanish Fork Valley.

This agreement, made and entered into this .... day of ...... between the Strawberry Valley Water Users' Association, a corporation, party of the first part, its successors and assigns, and .... of ......, Utah, party of the second part, ... heirs, administrators, executors, and assigns:

Witnesseth: That in consideration of the covenants of said second party hereinafter contained (and contained in subscription contract No. ....., executed by the second party for the stock of the first party, hereto attached and made part hereof), said first party hereby agrees that the water rights now vested in said second party, as evidenced by the decrees of the first judicial district court of the Territory of Utah and of the fourth judicial district court of Utah County, State of Utah, now in force and of record in the said fourth judicial district court, shall retain priority and right of use as therein decreed over the rights acquired under the subscription contract hereto attached.

Should the party of the first part fail to deliver additional water to said second party or should the Reclamation Service, established under the provisions of the act of Congress approved June 17, 1902 (32 Stat., 388), known at the reclamation act, fail to carry into effect the Strawberry Valley reclamation project, now under consideration under the provisions of said act of Congress, or should the supply of water from the Strawberry Valley project fail any year or succession of years after the completion and installation of said project, then the prior right to use the water of Spanish Fork River, as set forth in greater particularity in the decrees hereinbefore referred to, shall not be interfered with or hindered by the first party, but said rights as in said decrees determined shall be protected and preserved as such prior right by said first party for the use and benefit of said second party.

Said second party, in consideration of the aforesaid covenants of the first party, agrees, in addition to the covenants recited in the subscription contract hereto attached, that said second party will deposit in escrow with .... at Spanish Fork, State of Utah, the stock certificate or other evidence held by the said second party of the right or title to use the water now delivered or distributed to the second party by the ...... Canal Company, properly indorsed by said second party, the same to be transferred and delivered to the first party at or before the time, as announced by the Secretary of the Interior, when the United States is ready to deliver water to the lands of the said second party from the irrigation works of the Strawberry Valley project, constructed under the provisions of the reclamation act: *Provided*, that nothing herein shall be construed to interfere with or hinder the party of the second part in the full enjoyment of his right to the use of water by virtue of said certificates of stock or other evidence of right until the completion of said project, and the distribution of water thereunder as provided in this agreement and its subscription contract hereto attached.

In witness whereof we have hereto set our hands and seals the day and year first herein written.

STRAWBERRY VALLEY WATER USERS' ASSOCIATION,

[SEAL.] By ...., *President,*

Party of the First Part.

[SEAL.] ....,

Party of the Second Part.

Attest:

....,

[SEAL.] *Secretary.*

The ...... Canal Company covenants and agrees as follows:

That whereas the Strawberry Valley Water Users' Association, described in the form of contract hereto attached and made part hereof, as the first party, and other persons, stockholders in said company, signing contracts as above in form, and therein described as the second party, have entered into an agreement of which the aforesaid is a copy.

Now, therefore, said ...... Canal Company in consideration of the premises and covenants entered into by said first and second parties, hereby covenants and agrees that at or before the time, as announced by the Secretary of the Interior, when the United States is ready to deliver water to the lands under the canal system of the said canal company from the irrigation works of the Strawberry Valley project, constructed under the provisions of the reclamation act, the said Strawberry Valley Water Users' Association may take the proper steps by petition to the appropriate court of the State of Utah to secure the dissolution by decree of such court in accordance with law of the said ...... Canal Company.

This contract is made and executed on behalf of the said ...... Canal Company in pursuance of a resolution of the board of directors of ...... Canal Company, bearing date of ...., copy of which is hereto attached and made part hereof.

In witness whereof we have hereunto set our hands and seals this .... day of ...... A. D. 1905.

...... CANAL COMPANY,

[CORPORATE SEAL.] By ...., *President.*

Attest:

....,

Secretary.

These agreements seem to have satisfied all anxiety in relation to prior claims and the association stock subscription will cover all sources of water for the entire tract and should afford a basis for a most excellent system of administration in the affairs of the association.

ROADS AND BUILDINGS.

In order to facilitate construction on the tunnel and reservoir, it will be necessary to put the roads, to the nearest railroad points, in repair. A field examination indicates the advisability of having the main railroad supply point on the Rio Grande Western Railroad at Castilla Springs, in the Spanish Fork Canyon, thence to construct a road through the Diamond Fork Canyon to reach both tunnel portals and the dam site.

From Castilla to the west portal the distance is 23 miles, thence to the east portal by a feasible road route 7.5 miles, thence to the dam site 4 miles. Over a great part of this distance a crude road is already built, but a great deal of work must be done to make the route practicable for the transportation of materials for the project. A very satisfactory grade can be secured and the work will not be of an expensive character. All other road routes have been examined, but this is the most feasible one, and has the advantage of affording a permanent road from the Spanish Fork Valley to the storage reservoir after the project is constructed.

For camp buildings log structures will be put up, utilizing the aspen logs in the immediate vicinity. Such buildings can be cheaply constructed and be made very serviceable.

A telephone line is contemplated from Strawberry Valley to Spanish Fork, a distance over all of about 30 miles, affording a chance for long-distance connection at Spanish Fork with either the Rocky Mountain Bell or Utah Independent telephone lines to Salt Lake and other prominent points.

OPERATIONS IN WASHINGTON.

By D. C. Henny.

OKANOGAN PROJECT.[a]

The Okanogan project has for its object the irrigation of about 9,000 acres of land in northern Washington, lying along the right bank of Okanogan River. (See Pl. LVII.)

The work done during 1903 and 1904 is summarized in the Second Annual Report, pages 488–489, and the Third Annual Report (second edition), pages 606–609.

A board of consulting engineers, consisting of A. P. Davis, A. J. Wiley, and D. C. Henny, visited the project, April 24–26, 1905, and in its report to the chief engineer recommended that investigations be continued and completed.

WATER SUPPLY.

The water supply for the irrigation of lands under this project is obtained from Salmon Creek, a stream which drains an area of about 140 square miles. A gaging station was established on this stream in April, 1903, at Malott, Wash. The records from this station show a mean flow during the remainder of that year of 54 second-feet, giving a total of 28,500 acre-feet. The maximum flow was 429 second-feet, and occurred in June; the minimum flow, 16 second-feet, occurred in December. From July to the end of the year the flow ranged between 86 and 16 second-feet.

During 1904 the mean flow was 78 second-feet, giving a total of 56,460 acre-feet. The maximum flow (577 second-feet) occurred in April, and the minimum flow (11 second-feet) in January, February, March, September, and October. With the months of April to June, inclusive, eliminated, the flow ranged between 61 and 11 second-feet.

IRRIGABLE LANDS.

The irrigable lands have an elevation of 850 to 1,350 feet above sea level, and lie in a series of benches sloping toward Okanogan River. The soil is composed of sand, light loam, and volcanic ash. Irrigated lands in alfalfa yield a profit on a valuation of $100 per acre, and lands in fruit or nuts, for which the soil is specially adapted, will yield profits on a much higher valuation. Without irrigation the lands are practically worthless. The above conclusions are fully corroborated by statements of owners of lands now under irrigation in the vicinity.

LANDS NOW IRRIGATED FROM SALMON CREEK.

There are now irrigated from Salmon Creek 1,425 acres. The water rights of appropriators are being defined by a mutual agreement under which those having full water right will limit their claim to 3 acre-feet per acre for the land they actually irrigate, and those who are not at present able to get water for the entire season will limit their claim to 3 acre-feet per acre for two-thirds of the number of acres at present irrigated. Under this agreement the aggregate vested rights in Salmon Creek are found to be entitled to 4,050 acre-feet during the entire season, leaving sufficient water in a dry year for the irrigation of about 8,500 acres not now irrigated available for the project.

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[a] From report by C. Andersen, engineer.

STORAGE OF WATER.

Storage is being figured on for the complete retention of all flood waters of Salmon Creek in years of low run-off, for which purpose a total capacity of 13,000 acre-feet is required. In addition, storage of 5,000 acre-feet is considered desirable to hold over from a high to a low year.

With this capacity it is estimated that the minimum amount of water available for any one year will be 36,000 acre-feet, except in case of two successive low years.

The following four reservoirs have been considered: Salmon Lake, Conconully basin, Scotch basin, Brown Lake.

Salmon Lake is a natural lake about 2½ miles in length lying just east from the town of Conconully in a coulée branching off from North Fork of Salmon Creek. It is practicable to store a maximum of 18,000 acre-feet in this reservoir by building a low earthen dam across its outlet, about 1,000 feet long and with a maximum height for a short distance of 58 feet. Part of the storage is figured on by cutting down the outlet to a point about 15 feet below the ordinary stage of water in the lake. The elevation of low water will be about 2,280 feet.

Conconully basin lies immediately south of Conconully. The reservoir is to be formed by the construction of an earthen dam in Salmon Creek Canyon below the junction of North and West forks of Salmon Creek. This reservoir can be made to hold 16,000 acre-feet. The dam figured on is of the earth type, 80 feet maximum height and about 500 feet long. The elevation of low water will be about 2,230 feet.

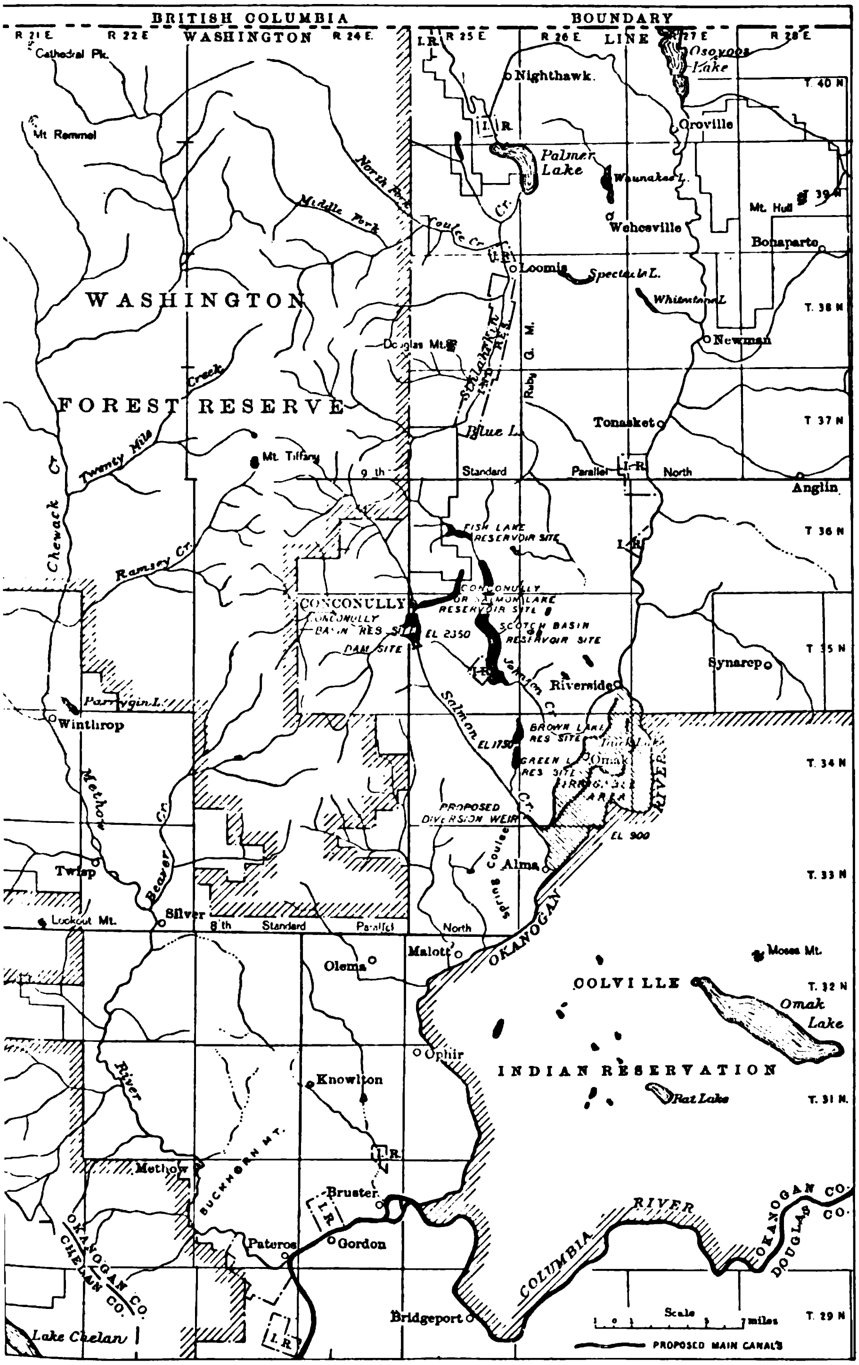
Scotch basin lies outside of the drainage area of Salmon Creek and offers the largest storage in the project. It occupies about 4 miles in length of the narrow coulée which is the upper portion of Johnson Creek, a small stream skirting the irrigable lands on the north. The material composing the sides of this coulée varies from limestone at the upper end to a good, sound marble at the dam site. A capacity of 14,000 acre-feet can be had at elevations between 1,440 and 1,513 feet. Borings have shown that solid rock below the bottom of the coulée occurs at a depth of over 70 feet. As a cut-off wall was deemed essential, the cost of a dam at this point was found to be prohibitive; moreover, the inlet canal from Salmon Creek as well as the outlet canal to the irrigable lands would be expensive, the former owing to its length, the latter owing to steep and difficult ground.

Brown Lake is a natural lake situated in a coulée draining into Salmon Creek. This lake offers excellent facilities for storage, but long expensive inlet and outlet canals would be necessary to connect it with Salmon Creek above and the irrigable lands below. A capacity of 9,000 acre-feet can be had between elevations of 1,574 and 1,638 feet, and to obtain this capacity a dam of the earth type has been estimated on, with a maximum height of 50 feet and a top length of 575 feet.

REPORT OF CONSULTING ENGINEERS.

Estimates of cost on the basis of various capacities for these several reservoirs and inlet and outlet canals have been made and preliminary designs of structures have been completed. The entire work was submitted to a board of engineers consisting of A. J. Wiley, Morris Bien, D. C. Henny, and Christian Andersen, who on October 9 reported on the project as follows:

> We find that the total area irrigable from Salmon River is 10,000 acres, of which there are now being irrigated 1,350 acres, the vested water rights whereof have been defined by preliminary mutual agreement.
>
> We estimate that the cost of irrigating the remaining 8,650 acres will not exceed $50 per acre, including ten years' maintenance.



GENERAL MAP OF PROPOSED OKANOGAN PROJECT, WASHINGTON.

We find that the people are willing and anxious to accept the project on the basis of the cost estimated and to comply with all the usual requirements preliminary to construction, and we believe that the land is ample security for the estimated cost of construction as stated above.

We therefore recommend:

First, that the sum of $432,300 be set aside for the construction of this project.

Second, that the construction be commenced as soon as the following conditions have been complied with:

(*a*) **That** formal agreements defining the water rights for at least 90 per cent of the 1,350 acres now irrigated be duly executed and that in connection therewith the perpetual use of Salmon Lake reservoir be granted to the United States by its present owners.

(*b*) **That** a water-users' association be organized and that at least 90 per cent of the 8,650 acres of irrigable land be subscribed.

(*c*) **That** contracts for the disposal of excess land be executed for at least 90 per cent of the excess area

Third, that the farm unit for the project be fixed at 40 acres of irrigable land.

Fourth, that in order that the work may be completed in time for the irrigation season of 1907 prompt action be taken for the authorization of this project.

YAKIMA VALLEY PROJECT.[a]

GENERAL STATEMENT.

Active investigation in the Yakima Valley was first begun in April, 1905, after it had become evident that those interested in the older irrigation canals were disposed to settle their existing water rights on an equitable basis without resort to process of law. (See Pl. LVII*a*.)

In the early spring of 1903 a reconnaisance was made of the Tieton scheme. It was then determined that no project could be undertaken contemplating taking water from streams the water rights on which were in such a chaotic condition.

In the anticipation of a settlement, either on an amicable basis or through the courts complete hydrographic data were obtained during the irrigating season of 1904 of the flow of all the principal canals and streams that furnish any considerable water supply during the dry season.

In February, 1905, the State legislature passed an act approved March 4, 1905, entitled "An act relating to the appropriation of waters of the State for irrigation purposes, granting to the United States the right to exercise the power of eminent domain in acquiring lands, water, and other property for rights of way, and for reservoirs and other irrigation works, granting to the United States certain rights in State lands and in the waters of the State, relating to water-users' associations, and declaring an emergency." Under this law a withdrawal of the waters of Yakima River and its principal tributaries and a list of the State lands over which rights of way were required and lands susceptible of irrigation under the Yakima project were filed with the State land commissioner May 10, 1905. About the same time active investigations in the field were begun.

Yakima River drains an area of 5,300 square miles west of the Columbia. Its normal low-water flow into the Columbia 10 miles above the mouth of the Snake, if unaffected by diversions from irrigating ditches, would be about 1,400 second-feet.

The highest recorded discharge during the nine years in which a station has been maintained on the river is 27,050 second-feet in 1901. The main river and its principal branches, the Naches and the Tieton, rise from the summit of the Cascade Mountains, draining an area above their confluence, of about 90 miles north and south and 60 miles east and west, approximately 2,570 square miles. About half of this area is arid and grows nothing but sagebrush and bunch grass, with no timber. The precipitation on this portion varies from 5 to 12 inches and contributes nothing to the low-water flow of the river. The balance of the area is covered with timber, varying in density with the amount of rainfall, which is from 12 to 100 inches.

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[a] From report by T. A. Noble.

The lower and arid portion of the valley, in which lie the lands which can be irrigated, is divided into five basins separated by basaltic ridges through which the river flows in narrow canyons and gaps. In the order of their position along the river from the Cascade Mountains to the Columbia, the basins are as follows:

Basins of Yakima River.

	Elevation.	Irrigable area.	Irrigated area.	Approximate population in 1900.
	Feet.	*Acres.*	*Acres.*	
Clealum	1,750-2,150	10,000	3,000	3,843
Kittitas	1,500-1,750	75,000	20,000	5,861
Yakima	1,050-1,500	100,000	50,000	8,914
Reservation	650-1,050	180,000	54,000	5,511
Columbia River	350- 650	230,000	9,000	453
Total		595,000	136,000	

VALUE OF LANDS.

The value of land increases very rapidly from the higher to the lower elevations, on account of the increased length of growing season and higher temperature. The higher lands, owing to the shorter season and greater rainfall, require less water for irrigation.

The principal criterion of the value of any irrigated land is its proximity to a ready and profitable market. Puget Sound, Columbia River basin west of the Cascades, and Alaska, being engaged principally in commercial, mining, lumbering, fishing, and allied pursuits, support a very large population, but a very small percentage of the accessible area is suitable for raising those crops that can be produced in the irrigated districts. Here is an ideal condition for an irrigated area—an adjoining humid area supporting a large population. The short distance to tide water, ranging from 99 to 250 miles, is also a favorable condition.

The irrigable lands are at comparatively low elevations, and the productiveness of the soil along Yakima and Columbia rivers is greater than in any other arid section of the United States, except in the extreme Southern States.

The growing season varies from seven to five months, according to elevation. On the lower unirrigated lands near Columbia River the temperature has been known to rise to 117° F.

SOIL.

The character of the soil varies in the different basins, being lighter and more sandy near the Columbia, light volcanic ash in the Reservation and Yakima basins, volcanic ash with more or less clay in the Kittitas basin, and an adobe clay in the Clealum basin. In places on the benches these soils are of considerable depth, but generally they form a covering of from 1 to 3 feet on top of porous gravel and river wash. In each of the existing irrigated areas a portion of the land has become swampy or alkaline by lack of proper drainage and an excessive use of water for irrigating.

WATER RIGHTS.

There are 55 canal systems taking water from Yakima and Naches rivers between Clealum and the mouth of the Yakima, not including numerous small canals taking water out of the smaller tributaries of the Yakima, which furnish but little to the low-water supply of the river. The total average amount of water diverted from Yakima River by these canals in August, 1904 and 1905, the amount of land irrigated in 1905, and the amount of land covered, was as follows:

Canal systems on Yakima River and tributaries.

Name.	Amount diverted.		Land irrigated in 1905.	Land under canals in 1905.
	August, 1904.	August, 1905.		
	Sec.-feet.	*Sec.-feet.*	*Acres.*	*Acres.*
Kittitas basin	265	241	23,000	32,000
Yakima Valley:				
Moxie Valley	144	153	12,000	15,000
Naches River	573	544	27,000	35,000
Sunnyside canal	605	626	34,000	69,000
Reservation canals	256	269	17,000	80,600
Canals in Columbia basin	160	154	8,000	21,000
Total	2,003	1,995	121,000	252,000
Amount flowing into Columbia River	112	100	....	....

The average diversion for these two years was at the rate of 1 second-foot for each 58 acres of land irrigated. During the month of August in both these years the river was practically dry at Prosser Falls, except the amount appropriated for power purposes, and in the last year there was a considerable shortage in some of the canals. With the enormous amount of additional lands that can be irrigated from the existing canals at a very slight increase in cost per acre, there will be an irresistible tendency in the future to enlarge and extend the canals and use more water from the river. The result of this tendency, if not checked by a settlement of all water rights affecting the flow of the main stream, will be to deprive those lower down on the stream of the water to which they are entitled and to make it unsafe to use the river for conveying stored water. A settlement of all water rights on the basis of the natural flow of the river in the years of lowest discharge is, therefore, necessary before any project can be approved. Such a settlement is now pending, and will not only make the way clear for the Government to undertake a project but will save to the water users endless expense and prevent the stagnation in business which is sure to follow in the train of the water-right litigation which has already been started.

TRANSPORTATION.

The Northern Pacific Railway traverses the center of the valley from the summit of the Cascades to Columbia River. The Columbia is navigable for 50 miles upstream from the point where the Northern Pacific crosses at Kennewick. The distance to transportation by water or rail from the farthest point in any irrigable land being investigated under the Yakima project is 20 miles. The average haul would be about 7 miles. By the construction of two short branches, one 20 miles and one 50 miles long, the average haul could be reduced to less than 4 miles.

STORAGE.

As all of the natural flow of Yakima River is already appropriated by users who have preserved their legal rights under the State law, storage is an essential part of any plan for the future development of irrigation in the valley. Five reservoir sites have been found and their capacity and cost of construction are being thoroughly investigated. It is expected that the average cost of these reservoirs will be reasonable per acre-foot, though they vary greatly in capacity and cost of development. They are as follows, in the order of their capacity and importance: Lake Clealum, Lake Kachess, Lake Keechelus, Bumping

Lake, and McAllisters Meadows. Topographic surveys of the reservoirs and dam sites at all of these except the latter have been made during the field season of 1905. Estimates are being made to determine the most feasible height of dams and cost per acre-foot. The maximum economical capacity of these reservoir sites will probably not be sufficient to irrigate all of the available land.

TIETON SUBPROJECT.

The Tieton scheme contemplates the irrigation of about 24,000 acres of land west and north of the town of North Yakima. It is divided into three areas, separated by distinct topographic features—Wide Hollow, Cowiche Basin, and Naches Ridge. The portion in Wide Hollow lies directly west of North Yakima and next to the Yakima Valley canal, which takes water from Naches River. The elevation is between 1,250 and 1,750 feet, and the distance from North Yakima, the nearest transportation point, is from 3 to 15 miles. Cowiche Basin is a very fertile valley between the two forks of Cowiche Creek, at from 1,570 to 2,140 feet elevation and 8 to 18 miles from North Yakima. Portions of it are already partially irrigated from Cowiche Creek. Naches Ridge is a flat ridge between Cowiche Creek and Naches River, about 2 miles wide and 11 miles long. The elevation is from 1,500 to 2,100 feet, and the distance from North Yakima 5 to 18 miles.

Within the area to be irrigated is considerable land on which no vegetation will grow, with shallow soil and loose rock lying on top of solid rock and hardpan. This land has been eliminated from the scheme.

The water is to be taken from the right bank of Tieton River about 16 miles above the mouth by means of a low masonry dam, so constructed as to allow all drift, moving silt, bowlders, etc., to readily pass over during high water. The canal line for a distance of 12 miles follows along a very steep hillside, involving the construction of a lined section and in places short tunnels to avoid steep rock cliffs. At the end of this section the line enters a tunnel 3,100 feet long through the ridge between Tieton and Cowiche valleys. From this point the canal will begin to reach irrigable lands and will be divided into two main branches, the left one irrigating Naches Ridge and the right carrying water for Cowiche Basin and Wide Hollow. The right branch follows an easy grade, mostly in earth construction, for 11 miles to a point opposite South Fork of Cowiche Creek, where it will drop to Cowiche Creek from an elevation of 2,110 to 1,800 feet. The canal will be taken up at this point, cross Cowiche Creek, and follow a very irregular hillside to the summit of a ridge between Cowiche Basin and Wide Hollow. This line from Cowiche Creek, for covering lines in Wide Hollow, would be in about equal amounts of soil and rock.

Surveys in the field have been completed for the season and estimates of construction are well advanced. The cost of construction per acre of land to be irrigated will be high as compared with other lands in the valley.

All of the water in the Naches, into which the Tieton flows, has been used or appropriated for irrigation or power, though only one small canal of 1 second-foot capacity takes water from Tieton River. It will be necessary, therefore, to replace all water taken from the Tieton during August and September with water stored within either the Naches or the Tieton Valley. The only two reservoir sites which have been found are Bumping Lake, on a branch of the upper Naches, and McAllisters Meadows, on Tieton River. The former has been surveyed and is believed to be the most feasible.

It is expected that this land, being near the town of North Yakima, where land values have been well established, will stand a high charge for water.

SUNNYSIDE SUBPROJECT.

On June 6, 1905, the Washington Irrigation Company submitted to the Secretary of the Interior an option to purchase its canal and lateral system, water rights, and all other property pertaining to its irrigation system, except the land still owned by the company, for which it was to retain a perpetual water right, but to pay the usual maintenance fee of

$1 per acre. In April, 1905, a board of consulting engineers made an examination of the property and recommended that a survey and examination be made.

The work of investigation was begun July 1, 1905. It was not considered advisable to go to any expense in investigating the feasibility of taking up the option until it had been settled whether the Carey land selection would be approved or disapproved. This selection is a checkerboard of even sections scattered throughout the area, which could be irrigated by an extension of the Sunnyside canal or by the Leadbetter scheme. To irrigate the lands not included in the State selection under this condition would be manifestly unfeasible. To irrigate the State lands selected under the Carey act by works constructed under the reclamation act is also considered unfeasible. After the State officials had in public meeting expressed themselves as willing to relinquish the rights of the State if the Government should construct a project in the Yakima Valley it was decided to proceed with investigations.

All lands under the Sunnyside canal have been classified as to ownership, water rights, and feasibility of irrigating. The conditions, up to the date of the option, were as follows:

Classification of lands under Sunnyside canal.

		Acres.
Lands for which water rights have been sold		38,800
Lands owned by the company for which they retain a water right, about		9,000
Total land under the canal that would not pay for a water right		47,800
Lands covered by the existing canal, not owned by the company, for which water rights could be sold by the United States	21,000	
Lands that can be reached by a 6-mile extension of canal	3,800	
Lands that can be reached by pumping above the canal for which water rights could be sold	5,000	
Lands that can be reached by an inverted siphon across Yakima River for which water rights could be sold	6,700	
Total lands that could pay for a water right		36,500
Total irrigable area that can be reached		84,300

This does not include the lands on Rattlesnake Flat that could be irrigated by an extension of the canal, as it is considered more feasible to irrigate these lands under the Leadbetter subproject.

Water rights under the canal are being sold for $30 and $40 per acre, with a maintenance fee of $1 per acre per year.

At present surveys in the field have been completed. The canal has been cross sectioned and all data collected which are essential to determine the cost and value of the property and the cost of betterment or enlargement for irrigating the lands under the canal as it exists and for covering additional lands that can be reached. Estimates of cost and a report regarding all essential features of the condition of the property will soon be complete.

The company owns one of the oldest water rights in the valley. Its appropriation was 1,050 second-feet from Yakima River. During August, 1905, it diverted an average of 626 second-feet.

LEADBETTER SUBPROJECT.

The Leadbetter subproject contemplates the irrigation of about 210,000 acres of land —180,000 acres on Rattlesnake Flat, between the Rattlesnake Mountains, Columbia River, and the north side of Yakima River; and 30,000 acres along the south side of Yakima River, and above the Kennewick canal.

It is proposed to divert water from Yakima River by building a dam above Prosser Falls to an elevation of 645 feet. The first 20 miles of canal will irrigate but little land. It will follow a very irregular and rocky hillside to the point where a siphon will conduct across the Yakima that portion of the water required to irrigate the lands on the south side of the river. For the next 12 miles the canal will follow a very irregular gravelly hillside, with many small ravines requiring culverts. At the end of the thirty-second mile the canal will branch and begins to irrigate the main body of land. At this point it is proposed to put in a direct water-power pumping plant, utilizing the power that can be developed by the 69-foot drop from the main canal to lateral B for pumping a portion of the water to an elevation of 139 feet above the main canal.

The relative elevations, capacities, and amount of land covered by the branch canals and main line are as follows:

Capacity, etc., of Leadbetter canal.

Name of lateral.	Approximate elevation.	Capacity.	Area covered.
	Feet.	*Sec.-feet.*	*Acres.*
Pumped Line	759	410	32,800
Extension of main canal	620	323	25,840
Lateral B	551	1,448	115,800
Kennewick branch	630	375	30,000
Main line:			
Siphon to drop			2,280
Head to siphon			1,400
Total for main line		2,556	208,120

The land under the canal varies in character from pure blown sand from the beaches of the Columbia to the best of loose rich soil. But two small patches of 60 and 40 acres are already irrigated. Aside from lands owned by the Northern Pacific Railway, and one body of about 15,000 acres, very little is in private ownership. The farthest distance to transportation from any point in the irrigable area to a boat landing on Columbia River, where connection can be had with the Northern Pacific Railway at Kennewick, is about 10 miles, and the average distance 5 miles. By building a branch line from Kiona, through the center of the irrigated area, the average haul could be reduced to 3 miles. The land lies between 350 and 640 feet elevation above sea level. The summer season is long and hot. Similar land at Kennewick grows four good crops of alfalfa annually.

KITTITAS SUBPROJECT.

The scheme known as the Kittitas subproject contemplates the irrigation of about 60,000 acres of land surrounding the irrigated district in Kittitas basin. The highest of the existing canals is the Cascade, at an elevation of 1,730 feet, which takes water from the left bank of Yakima River, at the mouth of the canyon between Clealum and Kittitas basins. To irrigate lands above this canal it will be necessary to construct a canal line the entire distance of 6 miles through the canyon separating these two basins, involving heavy construction with a large percentage of rock excavation on very steep slopes. One route taking water from the right bank of Yakima River near Easton, at an elevation of 2,140 feet, has been carefully surveyed. This line involves a number of very expensive inverted siphons, which, with the excessive length, make the feasibility doubtful. Two other alternate routes taking water from Clealum are being examined in order to obtain sufficient data to determine whether a more feasible route may be obtained. It is expected that estimates will be soon completed, which will determine definitely whether a project in this basin is feasible.

PRIEST RAPIDS PROJECT.[a]

SCOPE.

The Priest Rapids project contemplates the irrigation of desert land lying in Douglas, Benton, and Franklin counties, in the central part of Washington. The area is distributed along Columbia River between Pasco and the head of Priest Rapids, 50 miles above Pasco.

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[a] From report by L. J. Charles.

ACCESSIBILITY.

All the lands lie within 10 miles of the Columbia, which is navigable from Pasco to the foot of the rapids and from Trinidad to the head of the rapids, giving access to the Northern Pacific Railway at Pasco and the Great Northern Railway at Trinidad.

SUBDIVISIONS OF LAND.

The lands to be covered by the project are divided into three separate areas—the Priest Rapids, Pasco, and Rattlesnake tracts. The Priest Rapids tract lies on the east side of Columbia River, in Douglas County, bounded on the north and east by the Saddle Mountains and on the south and west by the Columbia. The Pasco tract is a portion of the area covered by the Palouse project and embraces the land around Pasco bounded on the north by the 450-foot contour and on the east, south, and west by Snake and Columbia Rivers. The Rattlesnake tract is on the west side of the Columbia and is bounded on the north and east by that river and on the south and west by the Yakima River and the 375-foot contour.

CLIMATIC CONDITIONS.

The growing season for the Pasco and Rattlesnake areas is about one hundred and sixty-eight days between killing frosts. The Priest Rapids tract is even more favored, as it is sheltered by mountains from sudden or severe changes in temperature. The season here extends from April 1 to September 15.

CLASSIFICATION OF LANDS.

The Priest Rapids tract lies in a series of benches. The lower bench is sandy and can be covered by a gravity canal. The other benches are volcanic ash superimposed on a gravel subsoil. Three-fourths of the tract is good irrigable land.

The Pasco tract is a volcanic sand and the soil is first class, being free from alkali and having good drainage.

The Rattlesnake area is similar to the Pasco tract, but has some outcrops of basalt rock near the north end and drifting sand near the center. The bulk of the area is of good quality.

ACREAGE.

The Priest Rapids tract can be divided into five sections, as shown by the following table:

Acreage in Priest Rapids tract.

Lift.	Line.	Length.	Gross area.
		Miles.	*Acres.*
Gravity, 0 feet	A	31.90	16,300
Pumping, 100 feet	B	25.43	13,680
Pumping, 200 feet	C	31.79	13,290
Pumping, 300 feet	D	57.66	46,950
Total		153.78	90,220

The gross acreage under the project is as follows:

Acreage under Priest Rapids project.

	Acres.
Priest Rapids tract	90,220
Pasco tract	25,000
Rattlesnake tract	44,000
Total	159,220

The Rattlesnake tract is a portion of the area under the Leadbetter subproject of the Yakima project, and may be considered as belonging to either that project or the one now under consideration.

DISTRIBUTION SYSTEM.

These tracts may be irrigated as follows:

The Priest Rapids tract, subdivision A, 16,300 acres by gravity canal, the remainder by direct pumping, taking the water for irrigation and power from Columbia River above Priest Rapids and dropping the necessary amount back into the river below the rapids, utilizing this drop for power.

The Pasco tract would be irrigated by water pumped from the Columbia by electric power generated at the Priest Rapids power house and transmitted 50 miles to the pumping plant. The main canal would be 25 miles long.

The Rattlesnake tract can be covered by a 50-mile gravity canal taken out of the main power canal or an extension of the same, and carried across the Columbia on a bridge in sec. 7, T. 13 N., R. 24 E. The diversion of water on the east side of the river and its transfer across the river was proved necessary by surveys made in 1904, which showed the diversion from the head of the rapids on the west side to be impracticable, as the first 12 miles of grade line lies along steep slopes and basaltic cliffs.

The Priest Rapids power and gravity canals are on gentle slopes and would probably encounter no rockwork. The canals on the higher levels would all follow around a steep bluff for 4 miles. The remaining portions of the canals are on gentle slopes containing no rock. The Pasco and Rattlesnake canals would encounter no sidehill work. The Rattlesnake canal would have a small percentage of loose and solid rock for the first 6 miles.

POWER-HOUSE LOCATIONS.

Two power-house locations have been considered. The first of these, in sec. 2, T. 13 N., R. 23 E., would require 6 miles of intake canal. The foundations of the power plant would be on solid rock. The discharge mains would be from one-fourth mile to 1¼ miles long. From this site it would be impracticable to pump to a greater height than 150 feet on account of the length of pressure pipes required to reach higher levels.

The second power-house site is near the eastern boundary of sec. 1, T. 13 N., R. 24 E. This site would require 13.2 miles of intake canal. The foundations would be on a formation of large bowlders. The pressure mains would vary in length between 300 and 1,000 feet. From this site the water can be forced up 300 feet.

The available head at both power houses would be practically the same—54 feet. Further study of the height of the river during the season of heaviest irrigation demand may increase this head to 60 feet.

INTAKE CANAL.

Water can be diverted at a point in sec. 28, T. 15 N., R. 23 E., and carried to either power-house site in a large canal whose construction would probably encounter no solid rock and be in nearly level cutting. A point on this canal line in sec. 33, T. 15 N., R. 23 E. offers a very favorable position for regulating gates, and by diking a draw in sec. 35, T. 14 N., R. 23 E. an ample settling basin can be provided. The Columbia carries very little silt or grit near the surface, but provision will have to be made to keep drifting sand out of the wheels.

SURVEYS COMPLETED.

In 1897 Mr. H. K. Owens made surveys of the Priest Rapids tract for the Northern Pacific Railway Company and submitted a report to them on the project. The first investigation of this project by the Government was made by Messrs. O. H. Ensign and T. A. Noble early in the summer of 1904. In October, 1904, the first party was put in the field. A detail sheet was made of the second power-house site referred to above. In February, 1905, the investigation was again taken up. A gage board was established at Julia, so that the fluctuations of the river could be recorded. A reconnaissance was made to determine the location and capacity of any reservoir site that could be found on the project at such an elevation that part of the pumping could continue the year round and the size of the units for pumping be decreased. The only such site found is in the northeast corner of T. 14 N., R. 24 E. It would be formed by placing a dam across the mouth of a swale. This reconnaissance proved that no reservoir was obtainable that would not be prohibitive on account of cost.

In March, 1905, contour lines were run out to determine the acreage in the Priest Rapids tract under each 100-foot contour up to 400 feet. At this time a plane-table survey of the power canal was made, on the scale of 1,000 feet to the inch, from the head of the rapids to the second power-house site. About 14 miles of topography in all was taken and a profile of the river made from the head of the rapids for the same distance downstream. From the topographic map of the canal line the selection of power-house site No. 1 was made and the characteristics of both sites determined. In June, 1905, three gage boards were placed along the river, one at the head, one at the middle, and one at the foot of the rapids. These are to give the variations in river height, and from their readings the available head will be determined. This concludes all the surveys so far made, and all estimates are based on the information thus obtained.

BIG BEND PROJECT.

The only sources of water supply available for the irrigation of the large area of land lying in the Big Bend of Columbia River are Spokane River and Cœur d'Alene Lake. The enormous expense involved in the diversion of water from either of these sources far exceeds the funds available for this purpose, and for this reason no field work on this project has been done during the past year.

PALOUSE PROJECT.

About 100,000 acres of land in the vicinity of Pasco, lying between Columbia and Snake rivers, may be irrigated from Palouse River. Active investigation was begun May 1, 1904, under the direct charge of C. Andersen. Storage reservoirs were located and studied, one on the main river below Hooper; one on Rock Creek, a tributary of the Palouse; one on Hangman Creek, a tributary of the Spokane; and one in Washtucna Coulee, below the point of diversion on the main river. Plane-table surveys were made of canal locations and of the irrigable lands. Borings were made and test pits dug at the various proposed dam sites and along the lines of canal, and careful estimates were prepared. A board of consulting engineers, consisting of A. P. Davis, A. J. Wiley, D. C. Henny, and T. A. Noble, considered the project in April, 1905, and recommended that for the present no further work be done on it for the following reasons:

(1) The most important feature of the project, the Washtucna reservoir, with a capacity of 200,000 acre-feet, is of doubtful feasibility, owing to the character of the rock underlying the gravel bottom. (2) The porous character of the ground in which the canals were to be excavated would necessitate concrete lining for long distances, to prevent excessive seepage. (3) The sandy character of the soil of the irrigable lands, in connection with climatic conditions and unavoidable seepage in main canals and laterals, would necessitate provision for an unusually large supply. (4) The cost per acre of irrigated land might be estimated at $63. (5) The entire estimated cost of $6,300,000 exceeds greatly the amount of money available for construction in the State of Washington, and partial construction, with gradual extension of the irrigated area, is impracticable.

CHELAN PROJECT.

The attractive possibilities of developing cheap water power at Chelan, for electric transmission to pumping plants along Columbia River, have led to a preliminary investigation and to the withdrawal from entry of unpatented lands lying along Lake Chelan and Chelan River, between the Washington Forest Reserve and Columbia River. A reconnaissance survey is in progress, and complete investigation may be desirable at an early date.

OPERATIONS IN WYOMING.

By H. N. Savage.

SHOSHONE PROJECT.[a]

Reports concerning the earlier work on the Shoshone project may be found in the Second Annual Report of the Reclamation Service, pages 507-510, and in the Third Annual Report, second edition, pages 626-631.

TOPOGRAPHIC SURVEYS.

In May, 1905, a party was organized for the purpose of completing the topographic work begun in September, 1904, on the south side of Shoshone River. This work covers an area of about 24,000 acres of irrigable land, which had been segregated by the State of Wyoming under the provisions of the Carey act, and which during the present year has been relinquished to the United States by the State land board. The topographic survey of this land was completed in September, 1905. There is now a complete topographic map, on a scale of 1,000 feet to the inch, with contour interval of 10 feet, of the entire area of irrigable land under the project as now planned. This map is of great value in making preliminary locations of all canal lines, headgates, and other structures for the distributing system, and for all purposes where a thorough study of the topography is necessary.

CORBETT TUNNEL.

The final location of the Corbett tunnel has been decided (Pl. LVIII), and borings have been made along the tunnel line for the purpose of determining the probable character of the material that would be encountered in driving the tunnel. The borings indicate that the material is shale and sandstone, and that concrete lining will be necessary. The tunnel will head in Shoshone River opposite Corbett station, on the Cody branch of the Chicago, Burlington and Quincy Railroad, the water being diverted into the tunnel by a weir 17 feet high and about 600 feet long. The line of tunnel is parallel to the general direction of the bluffs along the river, and at several points is close enough to them for adits to be excavated from the faces of the bluffs to the tunnel. This will give a means of dividing the tunnel into several short sections for construction purposes. The lower portal of the tunnel will be in a ravine about 17,000 feet from the upper portal in Shoshone River, this being approximately the total length of the tunnel. The area of the cross section of the tunnel will be 100 square feet, and its capacity 1,000 second-feet. At a point in the ravine above referred to, about 1,000 feet below the lower portal of the tunnel, will be constructed an earth embankment 40 feet in height, 150 feet in length on top, upstream slope 3 to 1, riprapped 10 feet below the surface of the water, downstream slope 2 to 1, top width 10 feet. This embankment will form a settling basin (Pl. LIX) in which practically all silt passing through the tunnel will be deposited, so that the water will pass into the main canal comparatively free from silt. A spillway will be constructed across a ridge between the settling basin and Shoshone River; through this spillway all surplus water that may enter the settling basin from drainage tributary to it will be discharged, and it will also serve as a regulator for the water entering the canal, the crest of the spillway being at the same elevation as the surface of the water in the canal. A sluicing tunnel 4 by 5 feet in cross section and about 250 feet long will be constructed through a ridge on the opposite

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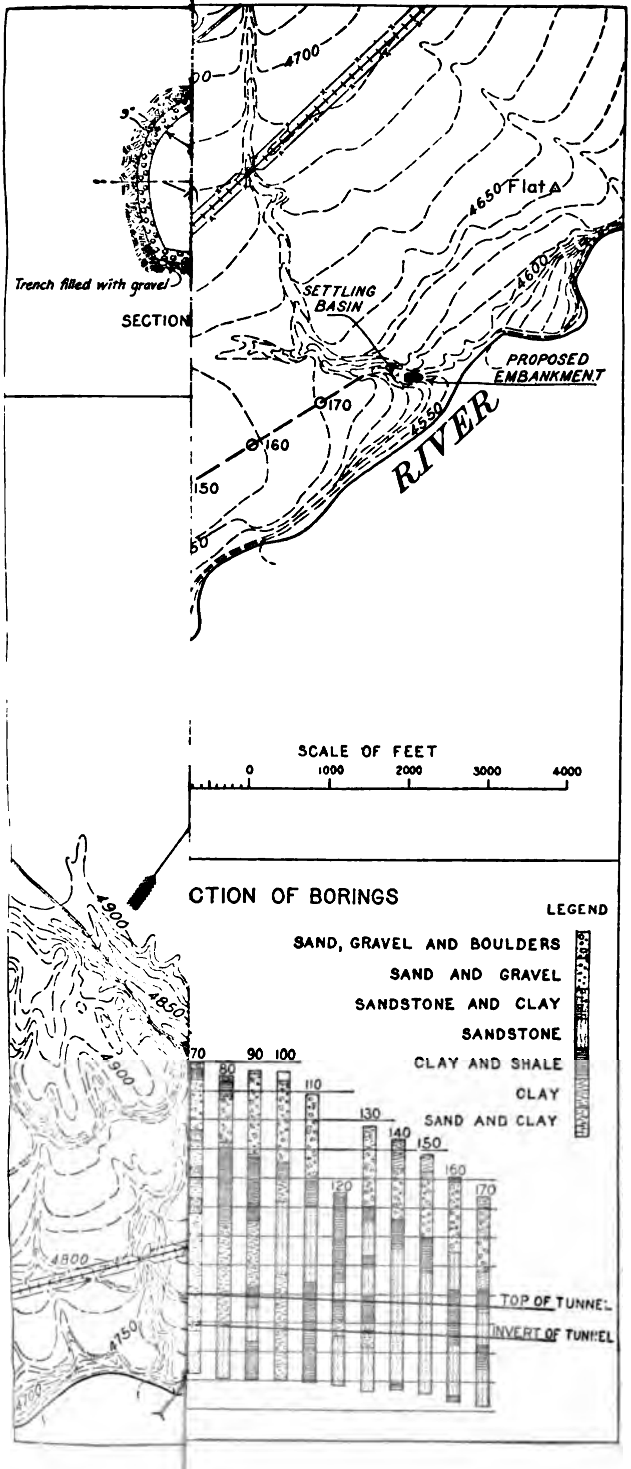
[a] From report by Jeremiah Ahern.

U. S. GEOLOGICAL UAL REPORT RECLAMATION SERVICE PL. LVIII



side of the embankment from the spillway for the purpose of sluicing out the silt that will accumulate in the basin (Pl. LX).

On September 6, 1905, bids for the construction of the Corbett tunnel were opened at Billings. Five bids were received, the lowest ($594,325) being that of Charles Spear, of Billings, Mont., to whom the contract was awarded September 16, 1905. The following is a schedule of the bids received:

Bids received for the construction of Corbett tunnel, Shoshone project, Wyoming.

Work or material.	Quantity.	Chas. Spear, Billings, Mont.		J. G. White & Co., New York City.		Patrick McDonnell, Duluth, Minn.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Tunnel, including lining, linear feet	17,000	$33.00	$561,000.00	$33.60	$571,200.00	$34.00	$578,000.00
Open-cut excavation, cubic yards	28,000	.50	14,000.00	.39	10,920.00	.60	16,800.00
Dry-rock paving in place, cubic yards	500	3.00	1,500.00	3.20	1,600.00	5.00	2,500.00
Gravel filling under rock paving, cubic yards	250	1.50	375.00	.40	100.00	1.00	250.00
Concrete in portals, cubic yards	400	7.00	2,800.00	7.80	3,120.00	6.00	2,400.00
Placing material in embankment, cubic yards	19,000	.35	6,650.00	.45	8,550.00	.40	7,600.00
Sluicing tunnel, lined, linear feet	250	20.00	5,000.00	10.30	2,575.00	30.00	7,500.00
Sluicing-tunnel shaft, pipe, gate, and gatehouse			3,000.00		1,685.00		5,000.00
Total			594,325.00		599,750.00		620,050.00

Work or material.	Quantity.	W. C. Bradbury, Denver, Colo.		Rod. D. Leggate, Butte, Mont.	
		Unit price.	Amount.	Unit price.	Amount.
Tunnel, including lining..........linear feet..	17,000	$39.75	$675,750.00	$45.00	$765,000.00
Open-cut excavation..........cubic yards..	20,000	.25	7,000.00	.25	7,000.00
Dry-rock paving in place..........do....	500	3.00	1,500.00	2.25	1,125.00
Gravel filling under rock paving..........do....	250	.75	187.50	1.00	250.00
Concrete in portals..........do....	400	6.00	2,400.00	8.00	3,200.00
Placing material in embankment..........do....	19,000	.30	5,700.00	.30	5,700.00
Sluicing tunnel, lined..........linear feet..	250	23.00	5,750.00	22.00	5,500.00
Sluicing-tunnel: shaft, pipe, gate, and gatehouse			2,250.00		3,000.00
Total			700,537.50		790,775.00

CANALS.

The main low-line canal will head at the settling basin and extend nearly to Frannie station, on the Cody branch of the Chicago, Burlington and Quincy Railroad, a distance of 42 miles. It will have a capacity of 1,000 second-feet for the first 9 miles, decreasing in size as the distributing canals leave it. The final location of this canal has been made.

The preliminary location of all the distributing canals covering the land in the vicinity of Garland and the final location of several of them have been made. This distributing system will cover the land known as the Garland flat, an area of about 50,000 acres. The portion of the main canal extending from Garland to Frannie, with its distributing system—not yet finally located—will cover approximately 30,000 acres in the vicinity of Frannie.

SOIL SURVEY.

A soil survey, under the direction of the engineer of soils, was started in September and will be completed during the present year. The result of this survey will determine the size of the farm units.

SHOSHONE RESERVOIR.

A survey of the 5,370-foot contour, which is 10 feet above the crest of the spillway, has been completed, the original survey of the reservoir extending only to the 5,350-foot contour. The capacity of the reservoir to the 5,360-foot contour—the flow line—will be 456,000 acre-feet. Contracts, subject to the approval of the Secretary of the Interior, have been made for the purchase of 2,919 acres covered by the reservoir. Negotiations are in progress for the purchase of the remaining 1,320 acres.

BORINGS.

BORINGS AT DAM SITE.

Diamond-drill borings at the dam site continued from November 1, 1904, to May 31, 1905, two drills being used, one operated by steam, the other by hand. Great difficulty was experienced in getting the casing down through the gravel and large bowlders overlying the bed rock, the size of the bowlders passed through varying from a few feet up to 28 feet. On December 9, 1904, boring No. 4 entered bed rock at a depth of 88 feet below the bottom of the channel. The boring was continued into the bed rock for 83 feet, making a total depth of 171 feet from the bottom of the channel to the bottom of the boring. Other borings were made farther downstream, and a location was selected for the dam where the average indicated depth to bed rock is about 65 feet below the bottom of the channel. The bed rock encountered in all borings is a very hard granite. A total of 15 holes were put down from 26 feet to 83 feet into bed rock, the total distance through gravel and bowlders being 819 feet and into bed rock 408 feet.

BORINGS AT CORBETT DIVERSION.

Wash borings made at the Corbett diversion indicate that the material under the river channel is shale and sandstone in alternate layers, overlain with about 10 feet of gravel. This is satisfactory material for the foundation of the diverting weir.

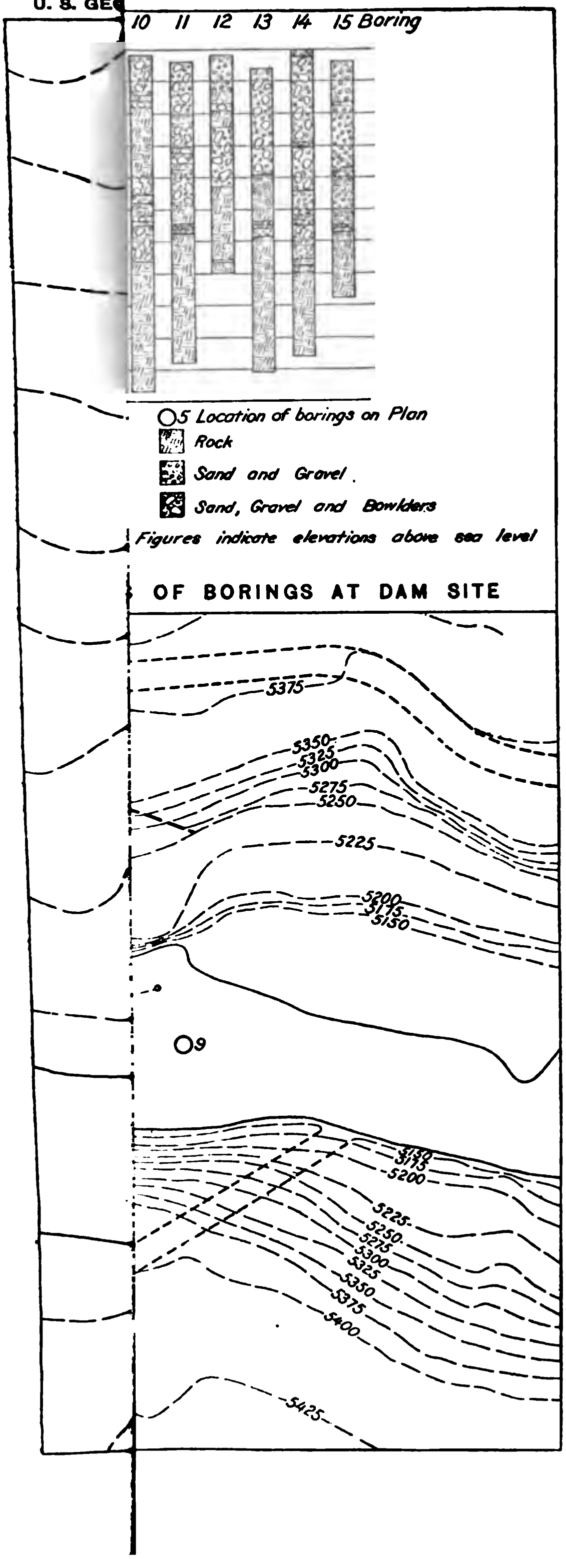
BORINGS AT WILLWOOD DIVERSION.

The Willwood diversion is a point on Shoshone River about 6 miles below the Corbett diversion. Here it is proposed to divert water for the purpose of reclaiming the land on the south side of Shoshone River. The borings indicate that a suitable foundation on sandstone for a diverting weir exists a few feet below the bottom of the channel.

SHOSHONE DAM.

The location selected for the Shoshone dam is a gorge in solid granite, about 70 feet wide at the bottom of the river channel and 200 feet wide at an elevation of 250 feet above the channel (Pl. LXI). These conditions seem to call for a type of dam other than that of a gravity section. In order to control the entire flow of the stream it was found that a dam 240 feet in height above the bottom of the channel, or 305 feet in height above the lowest point of the foundation, as indicated by the borings, would be required. After a careful consideration of the problem by a board of engineers, an arched dam, the radius of the center of the top being 150 feet, was decided on. The cross section adopted is of the following dimensions: Top width, 10 feet; batter of upstream face from top of dam to stream bed (245 feet), 15 per cent; batter of downstream face for same vertical distance, 25 per cent;

U. S. GE UAL REPORT RECLAMATION SERVICE PL. LXI



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from the stream bed to foundation (60 feet) both faces are vertical; width of bottom of section of dam, 108 feet (Pl. LXII). The dam will be constructed of concrete, in which pieces of granite rock weighing from 25 to 200 pounds will be placed by hand and rammed until well bedded. These rocks will be distributed uniformly throughout the dam and will form at least 25 per cent of its volume.

Plans and specifications for the construction of the Shoshone dam were prepared during the year under the direction of a board of engineers. On September 5, 1905, at Billings, Mont., bids for its construction were opened. Five bids were received, the lowest ($515,730) being that of Prendergast & Clarkson, of Chicago. On September 18, 1905, the contract was awarded to the above firm.

Bids received for the construction of Shoshone dam, Shoshone project, Montana.

Work or material.	Quantity.	Prendergast & Clarkson, Chicago, Ill.		Patrick McDonnel, Duluth, Minn.		Chas. Spear, Billings, Mont.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
Concrete:							
Base of dam .cubic yards..	19,000	$4.75	$90,250.00	$4.25	$80,750.00	$7.50	$142,500.00
Dam above base....do....	50,000	4.00	200,000.00	4.25	212,500.00	5.75	287,500.00
Outlet tunnel.....linear feet..	480	36.00	17,280.00	50.00	24,000.00	30.00	14,400.00
Temporary diverting works...	....	....	37,000.00	....	60,000.00	....	45,000.00
Excavation for foundation of dam:							
Class 1.......cubic yards..	32,000	1.60	51,200.00	3.25	104,000.00	2.00	64,000.00
Class 2..............do....	3,000	2.50	7,500.00	3.50	10,500.00	2.00	6,000.00
Class 3..............do....	1,000	3.50	3,500.00	3.50	3,500.00	2.00	2,000.00
Class 4..............do....	6,000	2.00	12,000.00	3.50	21,000.00	2.00	12,000.00
Spillway:							
Open-cut excavation, cubic yards....................	28,000	1.95	54,600.00	1.25	35,000.00	1.20	33,600.00
Tunnel excavation, cubic yards....................	7,000	5.50	38,500.00	9.00	63,000.00	2.50	17,500.00
Road tunnel......linear feet..	150	26.00	3,900.00	40.00	6,000.00	18.00	2,700.00
Total..................	....	....	515,730.00	....	620,250.00	....	627,200.00

Work or material.	Quantity.	W. C. Bradbury, Denver, Colo.		J. G. White & Co. New York City.	
		Unit price.	Amount.	Unit price.	Amount.
Concrete:					
Base of dam..................cubic yards..	19,000	$7.25	$137,750.00	$4.50	$85,500.00
Dam above base......................do....	50,000	6.25	312,500.00	3.50	175,000.00
Outlet tunnel.....................linear feet..	480	56.00	26,880.00	50.00	24,000.00
Temporary diverting works................	....	....	48,000.00	....	44,505.00
Excavation for foundation of dam:					
Class 1.......................cubic yards..	32,000	4.50	144,000.00	2.25	72,000.00
Class 2..............................do....	3,000	5.00	15,000.00	3.00	9,000.00
Class 3..............................do....	1,000	8.00	8,000.00	4.50	4,500.00
Class 4..............................do....	6,000	4.00	24,000.00	6.50	39,000.00
Spillway:					
Open-cut excavation.................do....	28,000	1.30	36,400.00	1.95	54,600.00
Tunnel excavation...................do....	7,000	4.40	30,800.00	6.50	45,500.00
Road tunnel.......................linear feet..	150	27.00	4,050.00	35.00	5,250.00
Total..................................	....	....	787,380.00	....	558,855.00

A spillway 300 feet long, connected with a tunnel 20 by 20 feet in cross section and about 500 feet long, will be constructed on the left side of the river for the purpose of discharging surplus flood waters. The spillway tunnel will discharge into the river 100 feet below the lower toe of the dam, and will have a capacity of 20,000 second-feet.

An outlet tunnel 10 by 10 feet in cross section and about 480 feet long will be constructed around the dam on the right bank of the river. The elevation of the floor of the tunnel at its inlet will be 10 feet above the bottom of the reservoir. (Pl. LXIII.) This tunnel will be constructed before work on the dam begins, and when completed will be used for conveying the water around the dam site during the construction of the dam. Designs of various types of gates for controlling the flow of water through the outlet tunnel are being made for the consideration of a board of engineers.

WAGON ROAD.

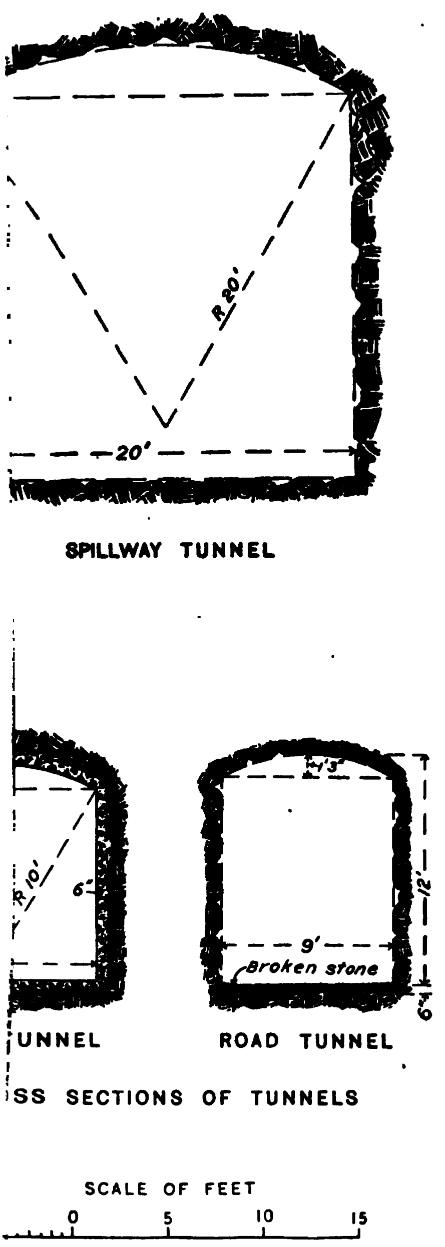
Work on the wagon road through Shoshone Canyon was continued from November 1, 1904, to July, 1905, when it was completed. For about one-half mile the construction involved very heavy rock work. On this portion of the road are two short tunnels. Over this road construction materials will be hauled to the dam site from Cody station, and after the construction of the dam it will be utilized as a portion of the road from Cody to the Yellowstone National Park, replacing the portion of the present road which will be covered by the reservoir.

EXPENDITURES.

The expenditures on the Shoshone project to September 30, 1905, for preliminary examination, final surveys, design of structures, construction of canyon road, construction of office buildings, quarters and storehouses, and administration were $162,944.39.

DE SMET PROJECT.

Since the last report no surveys have been made on this project, but stream gagings have been carried on continuously. At the time of the original surveys and report, sufficient stream gagings had not been made to determine the quantity of water available.



SPILLWAY TUNNEL

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ROAD TUNNEL

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POWER DEVELOPMENT AND PUMPING.

In connection with a number of projects, power development and pumping investigations have been prosecuted. In some cases power may be developed at the outlet of storage reservoirs, or at drops in main canals, and transmitted electrically to points where it may be utilized to supply water for additional irrigation by pumping from wells, from streams, from low-line canals to high-line canals, or from storage reservoirs for distribution to lands out of reach of gravity systems. Power is necessary in some cases to pump seepage water, that lands may be drained of water which has come from the irrigation of lands at a higher elevation.

Some projects that have been investigated depend wholly on pumping to get the water upon the land. For one class of these projects it is contemplated to develop power wherever natural water-power sites exist near a proposed project, and to utilize the power either by directly connecting water wheels to the pumps or by transmitting it to a distance and pumping by means of motor-driven pumps.

For another class it is contemplated to install steam-power plants where cheap fuel in the form of coal or oil can be found, to pump water from a large system of wells sunk where the underground supply of water is abundant and reliable, or from any other source of water, such as lakes or rivers. In some places these plants can pump the water directly; in others the power must be transmitted considerable distances.

In many projects it is necessary to construct some sort of a power plant to cheapen the cost of construction work of such structures as dams, tunnels, etc.

The study of the power development and pumping features of the several projects is under the direction of Mr. H. A. Storrs, for the Atlantic slope, and of Mr. O. H. Ensign, for the Pacific slope. The work of these engineers consists in investigating the power and pumping possibilities and in preparing designs and estimates of the cost of power plants, transmission systems, wells, pumping plants, fuel supplies, etc.

The principal power and pumping projects thus far investigated are briefly outlined below:

Arizona.—In connection with the Salt River project, designs have been worked out for a permanent power plant at the Tonto dam for generating 3,600 kilowatts or more, as may be found necessary, to be transmitted electrically to Salt River Valley, there to be used for pumping water from wells for irrigation.

Power may be obtained by utilizing water diverted from the Salt River above the reservoir and delivered to the power plant by a power canal located above the water line of the reservoir when full, and also from the water drawn directly from the reservoir. All the water will be utilized for irrigating purposes. The power canal is about completed and the apparatus for the temporary water-power plant is now being installed and will soon be in operation.

A temporary steam plant has been in operation for over a year, and since February has furnished power to the cement mill for running it at about one-half capacity. This plant will be shut down as soon as the water-power plant is put into operation.

Specifications have been advertised and issued covering water wheels and generators for the permanent plant, one unit of which is to be purchased and installed as soon as the work on the dam has progressed sufficiently far to allow this to be done. This unit is needed to insure a continuous supply of power throughout the construction work on the dam.

Estimates of the final cost of the power and pumping features of the Salt River project have been prepared, the final cost to depend upon the extent to which it is found, by actual development, the pumping system can be carried, the expenditure to be proportionate to the amount of water developed by pumping.

California.—Preliminary designs and estimates for a power plant of 1,200 kilowatts have been prepared, to be placed at a drop in the main canal of the Klamath project. The power is to be transmitted about 3½ miles and used to pump water from Lost River to about 10,000 acres of land lying above the main canal.

Some consideration has been given to the possibility of developing power on Klamath River below Keno and transmitting the power electrically to drive pumps for raising water to Butte Valley. Surveys have not yet been carried far enough to permit estimates to be prepared.

Idaho.—As a result of detailed study of local conditions and comparative estimates of cost of various designs for the fore bay, power plant, and tailrace to be located at the diversion dam of the Minidoka project, the earlier plans for a long fore-bay canal from the dam to a power plant located about half a mile downstream were modified, and provision has been made in the design and construction of the diversion channel to enable the future power plant to be erected immediately below the masonry dam which spans the diversion channel. Gate openings for the penstocks of the generating units have been provided in the dam, and the diversion channel has been widened and deepened to provide an adequate tailrace for a power plant containing six units, each discharging 600 cubic feet per second and developing 2,600 electrical horsepower under 50 feet head.

The plans as developed contemplate the erection of an electric generating station as described above, the erection of a transmission line about 12 miles long to pumping stations on the south side of Snake River, and the installation of pumping machinery, consisting of electric motors direct connected to centrifugal pumps. About 7,000 horsepower would thus be utilized in pumping water for about 52,000 acres which lie too high to be reached by gravity canals. The power would be procured without wasting water, since the prior rights of irrigators lower down the Snake River require that the water to which they are entitled be allowed to pass the Minidoka dam throughout the irrigating season. Hence the power needed for pumping purposes can be obtained at the bare cost of installing the necessary water wheels to handle the water discharged under the pressure head due to the diversion dam. The diversion dam having been built to raise the water into the gravity canals, its entire cost is chargeable to the lands supplied by gravity. Hence the lands to be reached by pumping can be brought under irrigation at a cost per acre for power and pumping plants and canal systems no greater than the cost per acre for the gravity works. Plans and estimates of the power and pumping system have been worked out in some detail.

Under the Payette-Boise project the construction of the proposed diversion dam in Boise River will afford water power which could be developed by installing an electric generating station to utilize the water which must pass the dam to supply the canal systems farther downstream. With the proposed height of the dam a head of 28 feet would be secured, and the minimum quantity of water available would be 400 cubic feet per second. This would yield about 1,000 electrical horespower, which may be used for pumping water or for commercial purposes in and near the city of Boise.

In order that provision might be made to utilize this power when the dam shall be constructed, plans and estimates for an electric-power plant have been prepared.

Kansas.—The Garden City project, described elsewhere, contemplates pumping water from about 230 wells, arranged in groups of ten, by using electrically operated centrifugal pumps. Power would be distributed to about 23 pumping stations from a central electric-generating station. Plans and estimates have been made comparing various types of prime movers, electrical apparatus, and pumping units. The aim has been to combine low first cost and reliability with flexibility and economy of operation. Colorado lignite and crude oil are available for fuel. Part of the water pumped will pass through the generating plant to be used for condensing and cooling purposes. It is planned so to design the system that the speed of the pumps can be controlled from the central station.

By the use of the proposed special types of apparatus a very efficient system is assured and the cost of the item of labor will be reduced to a minimum.

Montana.—During the winter of 1904 plans for a pumping plant on the Huntley project, to be located at the first drop in the main canal, about 14 miles below the headworks, were prepared by H. A. Storrs, electrical and mechanical expert, at Denver, working with W. E. Swift, engineer of the project, under the direction of H. N. Savage, supervising engineer. The plans call for two units, consisting of water wheels connected directly to the pumps which they drive. The required power is obtained by passing through the wheels the water to be used for irrigation on lands lower down on the canal. The available head is 34 feet. The pumps take water from the main canal above the pumping station and deliver it, with a life of about 46 feet, through a pipe line about one-third mile long, to a higher bench containing about 5,000 acres. The pumping station (exclusive of machinery), the fore bay, by-pass, and tailrace were included in the specifications for the structures on the main canal, issued by the Department April 29, 1905. The contract for the pumping station, by-pass, and fore bay was entered into with W. D. Lovell, Minneapolis, Minn., July 24, 1905. Contract for the pumping machinery will be made at an early date.

Preliminary plans and estimates have been prepared from data furnished by R. S. Stockton for the proposed Crow Indian project, and by C. C. Babb for Marias River development as part of the Milk River project.

North Dakota.—The essential features of all the proposed pumping projects for North Dakota are: Missouri River, furnishing an abundance of water; extensive deposits of lignite adjacent to the pumping plants, insuring a cheap and almost inexhaustible fuel supply; and areas of excellent land on the river benches at elevations above the river not too high to be economically provided with water by means of pumping.

Missouri River carries considerable quantities of silt at all seasons. This favors the use of centrifugal in preference to plunger pumps. The river water is always suitable for cooling gas engines and for condensing water for steam engines, but requires settling for use in steam boilers. If steam turbines be used, the water from the condensers may be returned to the boilers and only a small settling basin would be required to supply the loss. Gas engines have the advantage of requiring no settling basin.

The normal rise and fall of the water level in the river is less than 10 feet, but ice gorges occasionally produce an abnormal rise lasting a few hours, amounting sometimes to 20 feet or more. Pumping plants on the river bank must be so located and designed as not to suffer from these excessive high-water levels.

The Missouri is continually shifting its channel and eroding its banks. Pumping plants on the river banks at the water's edge must be protected by riprapping, brush mattresses, or other means. These means, to be effective, must be expensive, and if inadequate might permit the destruction of the pumping plant in a single day. To avoid this danger the pumping plants are, so far as possible, located back from the river, at the foot of the bench above the river bottom, and an intake canal is constructed across the bottom to admit water from the river to the suction chamber of the pumps.

The use of brown lignite, so abundant in western North Dakota, as fuel in the proposed pumping plants has required extensive investigations to determine its location, quality, cost of transportation, and efficient means for transforming it into power. Along the river banks, from the Montana line to the vicinity of Coal Harbor, outcrops of veins of workable thickness may be seen in great numbers. Only those veins which are at least 6 or 7 feet thick can be mined at reasonable expense. To avoid extensive timbering, the upper 1 or 2 feet of the coal vein is allowed to remain as a roof for the galleries. The coal is usually overlain with clay, shale, or other loose, weak material, which would fall if the entire vein of coal were removed. Practically no rock formation is found above the lignite except occasional thin layers of soft sandstone. Even the roof of coal must be supported somewhat on account of its tendency to slack and crumble when exposed to the air. The veins are usually horizontal, or nearly so, and not much underground water is encountered. The average cost of mining in some of the older well-equipped mines is 60 to 70 cents per ton.

The coal may be carried from the mines to the pumping plants by railroads, which can deliver the coal directly into bins at the plant, or by short tramways from mine to plant. Some pumping plants can be located almost at the mines, and possibly transportation by river barges may be economical in some localities.

As a fuel this brown Dakota lignite differs essentially from eastern steam-producing coals. When mined it contains 35 to 40 per cent of moisture. It readily loses about half of this if pulverized and air-dried. Averages of artificially dried samples show about 50 to 55 per cent of fixed carbon, 35 to 40 per cent of volatile hydrocarbons, and 5 to 10 per cent of ash. The commercial value of lignite as fuel has been underrated, because the steam plants in which it has been tried have not been properly designed to secure its full heating value. On account of the high percentage of both moisture and gases, the latter volatile at moderate temperatures, some type of gas-producing furnace is required if a reasonable boiler efficiency is to be obtained. At the St. Louis coal-testing plant of the United States Geological Survey experiments with this lignite in a producer plant furnishing gas directly to gas engines have shown that it is well suited to this use, but no commercial plants of this kind have yet been installed.

Tests made by H. A. Storrs, in Denver and vicinity, with North Dakota lignite burned in boiler furnaces, specially designed for low-grade Colorado coals, gave an evaporation of about 8 pounds per pound of dry coal, which is nearly double the evaporation secured in several typical commercial power and lighting plants in North Dakota.[a]

The lands to be supplied by the pumping plants are usually well-defined, consisting of a river bottom and a series of benches. The bottom lands require a lift of about 25 or 30 feet from low-water level in the river, and the benches require additional lifts of about 25, 50, and 75 feet. The average extent of each of these several areas is 3,000 to 5,000 acres.

Usually pumping systems will supply from 10,000 to 30,000 acres with maximum pumping lifts not exceeding 100 feet, the average lift being usually 50 feet or less. The complete system usually includes a main pumping station, where all the water for the several benches and the bottom lands is pumped from the river into the main canal. From this canal water is distributed, through the laterals, over the bottom lands. Along this canal at favorable points, selected according to the topography of the tract, secondary pumping plants are located, and water is pumped through pressure pipes into the canals that supply the bench lands.

On some of the smaller tracts it is feasible to concentrate all the pumps at a single station, where water is taken from the river and pumped directly into canals at the required elevations. This arrangement effects a saving of cost for both installation and operation. When the nature of the ground will not permit this, on account of the prohibitive costs for long-pressure pipes, heavy canal construction, etc., a central electric generating plant, built in connection with a main pumping plant and supplying electric power for the operation of the secondary pumping stations, will insure the minimum cost of operation. At the main power plant automatic devices for handling fuel will be warranted and the use of larger units will insure the best efficiency.

By combining the power and pumping machinery in a single station water for condensing purposes is available at practically no additional expense. The secondary pumping stations, containing only electrically operated pumping units, stationary transformers, and switches, will require the minimum of labor. The total saving effected by the high efficiency of the system and the reduction of labor costs will enable the water to be pumped into the several canals at an estimated cost for labor, fuel, and maintenance of three-quarters of a cent to 1 cent per acre-foot per foot of lift. Smaller systems, where a resort to electrical transmission of power from the main to secondary pumping plants is not warranted, will require steam or gas engines to be installed at the main and at one or more secondary plants, and fuel will have to be delivered to each plant. In such cases, however, the estimated operating costs for pumping will not exceed 1 cent per acre-foot per foot of lift, the coal mine or railroad being favorably situated for delivering fuel to the several plants.

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[a] Second Biennial Report State Geological Survey of North Dakota; Frank A. Wilder, State geologist.

Oregon.—Estimates have been prepared for pumping plants in connection with Malheur and Owyhee projects. Some of the water is to be pumped by electrically transmitted power from a power plant located at Harper reservoir and some by utilizing the drops in canals where turbine water wheels will be combined with centrifugal pumps.

Similar preliminary estimates have been furnished in connection with the Chewaucan and Ana River project.

Washington.—Preliminary estimates have been furnished for a pumping plant to be located at Priest Rapids for pumping water directly on the lands immediately adjacent, and also for pumping water on the lands near Pasco, these pumps to be driven by power electrically transmitted from Priest Rapids.

Further surveys and investigations have furnished the data upon which final estimates are now being prepared for the consideration of a board in the immediate future.

In connection with the Leadbetter project estimates have been prepared for a direct pumping plant, utilizing a drop in the main canal to develop power directly applied to pumps for irrigating 32,800 acres of land.

LAND CLASSIFICATION.

Arizona.—No work has been done in this State in land classification.

California.—For the Yuma project land classification carried out by Department of Agriculture has been used as basis of farm unit maps. These have been completed so far as is possible until there is an adjustment of land office subdivisions of certain parts of the project. Data collected in this soil examination have proved useful in planning drains for the project.

For the Klamath project preliminary studies have been made in the field and laboratory to determine the agricultural value of the lake bottom and swamp lands. Certain areas of these lands are of such questionable value that it is deemed best to postpone their irrigation. As a whole, however, the lands of the project are fertile and should make first-class farms.

Colorado.—Land classification and farm unit maps have been completed of the Uncompahgre project. First-class fruit land has been subdivided into 40-acre farms, and other land suitable for growing grain, sugar beets, and alfalfa has been divided into 80-acre farms.

Idaho.—Farm unit maps have been completed of the Minidoka project. A study has been made of the soil conditions to determine the necessity for drainage. The freedom of these lands from alkali and the porous subsoil insure the soil from damage from seepage water and alkali if proper amounts of water are used in irrigation. The necessity for drainage exists only on very limited parts of the project.

Montana.—Farm unit maps have been prepared of the Huntley project. Soil classification indicates the necessity of draining parts of the project to insure damage from rise of water and alkali.

Nebraska.—Land classification will be completed of the interstate canal during November, 1905. Farm unit maps will then be prepared. Farms will contain on the average 80 acres of irrigable land. A reconnaissance has been made of the agricultural possibilities of the Goshen Hole subproject, indicating the general excellence of the soils.

New Mexico.—During the spring of 1905 a preliminary classification was made of the soils of the Carlsbad project. Gypsum soils were considered unsafe for irrigation and were classed as third-class land. Areas of first and second class land sufficient in size to use all available water were outlined.

Nevada.—Portions of 10 townships have been classified and farm unit maps are being prepared.

North Dakota.—Lands have been classified in detail and drainage plans outlined for the Lower Yellowstone project. Farm unit maps will be completed in November, 1905. The most desirable size for farms on this project will be 80 acres.

Oregon.—Farm unit maps have been filed of the Malheur project.

South Dakota.—Land classification has been completed and farm unit maps are being prepared of the Belle Fourche project. The size farm selected is 80 acres irrigable land.

Washington.—Preliminary classification has been made of the soils of the Palouse project.

Wyoming.—Land classification of 50,000 acres under the Shoshone project will be completed in October, 1905. Farm unit maps, with 80-acre farms, will then be prepared.

Work is now being planned to complete farm unit maps on all projects under construction as fast as land will be opened for settlement.

CEMENT TESTS.

EXPERIMENTAL WORK.

The cement-testing laboratory at the Denver office was established early in January, 1905, but before that time—from July 30, 1904, to November 30, 1905—work had been done at the laboratory of the Denver Union Water Company, and at the laboratory of the Portland Cement Company, Portland, Colo., and the results of the tests thus made are given in the accompanying table. The tests have included about 26,000 barrels, embracing five brands of Portland cement, intended for use on six different projects.

The companies manufacturing these five brands of cement are the Iola Portland Cement Company, Iola, Kans. (Iola brand); Illinois Steel Company, Chicago, Ill. (Universal brand); Portland Cement Company, Portland, Colo. (Ideal brand); Portland Cement Company of Utah, Salt Lake City, Utah (Red Diamond brand); Western Portland Cement Company, Yankton, S. Dak. (Yankton brand). The works of each of these companies have been visited either for inspecting the plant or for conducting tests, or both, and samples have been collected from each plant, representing the raw materials used and the state of the materials during the several stages of manufacture until the finished product is obtained. These samples are now retained at this laboratory. Reports have been made regarding each of these plants as to capacity, equipment, methods of manufacture, etc.

In addition to these regular tests of cement for construction work, occasional sets of long-time tests have been made of each brand, covering periods of 3 and 6 months, 1, 2, 3, 5, 7½, and 10 years, in addition to the 7 and 28 day periods of the regular tests, each set consisting of 5 neat and 5 sand briquettes for each period. The results of these long-time tests are included in the table.

Other experimental work has consisted of sand tests, sand-cement tests, and tests for permeability. These tests have not been tabulated for presentation here, but the general results obtained will be briefly stated. Sand tests have been made for the Engle (Elephant-Butte dam), Hondo, Minidoka, North Platte (Pathfinder dam), and Uncompahgre Valley projects, samples of the material available for use as sand on those projects having been sent to the laboratory for tests to determine which materials among those available would be the best for use on construction work. The materials sent in consisted of natural sand and of stone from which artificial sand was made by crushing and grinding it to about the fineness of the screenings from a stone crusher in actual use, it being assumed that in some cases such screenings may be used as sand in making mortar or concrete. The main tests have been those for tensile strength, a number of sets of long-time tests having been made of the various materials as well as more numerous sets for short periods. In addition to the tests of tensile strength, mechanical analyses have been made on a set of sieves ranging from No. 10 to No. 200, showing the granulometric composition of each sample. Tests have also been made for per cent of voids, and the specific gravity of each sample of stone has been determined. In general, it may be stated that the coarse sands give a higher tensile strength than the finer grades, especially for the shorter periods, but that the finer sands gain somewhat faster than the coarser in the tests for longer periods. The artificial sands made from the samples of stone submitted include limestone, trap rock, granite, and sandstone, the results for tensile strength showing values in the order named, those for limestone in particular being remarkably high and those for granite being about the same as would be obtained for a good grade of natural sand.

The use of sand cement has been under consideration for some projects where there would be a long haul for cement from the railroad station to the site of the work, and where sand cement could be made by putting up machinery for grinding sand and cement together, and an extensive series of tests was therefore made to see how such material compares in strength with ordinary cement, the claim being made by the proprietors of the process that cement and sand mixed in equal proportions and ground approximately to such fineness as to pass a No. 200 sieve will, when used as a cement, give practically the same tensile strength on sand tests as the cement from which it is made. Eighteen full sets of long-time tests have been made of this material, several different grades of sand having been used in making the sand cement and this being tested both with standard testing sand and with various grades of natural sand. The results of the tests so far show an average decrease of about 20 per cent for the sand cement from corresponding tests of the cement from which it was made.

For making tests of the permeability of cement mortar under water pressure, apparatus has been employed similar to that used for an extensive series of like tests made in connection with the construction of the Wachusett dam of the Metropolitan Water Works of Massachusetts, at Clinton, Mass., in 1901–1904. The experiments made here thus far have included tests of materials from the site of the Pathfinder dam, of sand cement, and of artificial sand made from limestone similar to that used for tests of tensile strength. The results for mortar made with sand cement show that material to be somewhat more permeable than ordinary mortar, but do not indicate a very marked difference in permeability, while the result thus far obtained for limestone sand show that it is superior to ordinary sand. This result, together with the high tensile strength indicated, would seem to show that limestone sand is a valuable material for use in cement mortar or concrete. Perhaps it should be noted in this connection, however, that all the limestones tested here were comparatively hard and no doubt gave better results than could be obtained with softer limestones.

Cement tests made at Denver laboratory, July 30, 1904, to November 1, 1905.

Brand.	Number of barrels.	Project.	Composition of briquettes.	Fineness.		Setting time.				Specific gravity.
						Initial.		Final.		
				Per cent passing No. 100 sieve.	Per cent passing No. 200 sieve.	Hours.	Minutes.	Hours.	Minutes.	
Ideal	9,212	Salt River and Pathfinder.	Neat	94.9	71.6	2	42	6	29	3.08
			3 to 1	......	......	......	......	......	......	......
Iola	924	Pathfinder	Neat	94.9	74.1	4	49	9	33	3.16
			3 to 1	......	......	......	......	......	......	......
Red Diamond	8,650	Minidoka	Neat	96.3	71.4	2	55	6	24	3.14
			3 to 1	......	......	......	......	......	......	......
Universal	6,000	Lower Yellowstone and Huntley.	Neat	97.7	75.1	3	15	7	15	3.20
			3 to 1	......	......	......	......	......	......	......
Yankton	1,000	Belle Fourche	Neat	95.5	65.3	3	......	8	30	3.20
			3 to 1	......	......	......	......	......	......	......
Total	25,786	......	Neat	96.1	72.2	2	59	6	49	3.16
			3 to 1	......	......	......	......	......	......	......

Brand.	Composition of briquettes.	Tensile strength.											
		1 day.		7 days.		28 days.		3 months.		6 months.		1 year.	
		Number of briquettes.	Pounds per square inch.	Number of briquettes.	Pounds per square inch.	Number of briquettes.	Pounds per square inch.	Number of briquettes.	Pounds per square inch.	Number of briquettes.	Pounds per square inch.	Number of briquettes.	Pounds per square inch.
Ideal	Neat	10	408	614	653	604	722	15	724	15	698	5	657
	3 to 1	......	......	614	265	604	343	15	434	15	450	5	477
Iola	Neat	10	290	93	718	65	760	20	815	10	730	10	777
	3 to 1	......	......	93	307	65	426	20	457	10	497	10	477
Red Diamond	Neat	20	335	706	608	669	668	20	679	15	634	5	750
	3 to 1	......	......	706	295	669	385	20	428	15	445	5	501
Universal	Neat	5	352	300	562	220	727	......	......	......	......	......	......
	3 to 1	......	......	300	252	220	386	......	......	......	......	......	......
Yankton	Neat	28	304	55	551	55	669	5	720	......	......	......	......
	3 to 1	......	......	55	253	55	364	5	438	......	......	......	......
Total	Neat	......	......	1,768	620	1,613	699	60	739	40	682	20	740
	3 to 1	73	328	1,768	277	1,613	371	60	440	40	460	20	481

COST OF CEMENT.

The table below shows the average price of cement in 1903 and 1904, the average bids, and the contract prices. The table below is a partial list of the cement contracts awarded by the Reclamation Service. The table on page 361 contains a partial list of the bids thus far made by various cement companies for furnishing cement under the Reclamation Service specifications.

Prices of cement.[a]

State.	Average price in 1903.	Average price in 1904.	Price in Reclamation Service contracts.	Average of bids in 1905.
California	1.62	1.42	1.52	1.66
Colorado	1.69	1.30	1.40	1.25
Illinois	1.52	1.09	1.03	1.14
Kansas	1.26	.81	1.00	1.10

[a] Bids and contracts specify that cement should be 95 per cent fine. Prices for 1903 and 1904 are based on commercial grinding.

Contracts for cement.

Project.	Date.	Company.	Location of works.	Price at works.	Price at project.
Truckee-Carson	Sept. 25, 1903	Spreckles Bros. Co	San Francisco	....	$2.55
Minidoka	Aug. 25, 1904	Utah Portland Cement Co	Salt Lake City	....	2.95
Hondo	Jan. 10, 1905	Western Cement Selling Co	Denver, Colo	....	2.83
North Platte	Mar. 16, 1905	Iola Portland Cement Co	Iola, Kans., 92 per cent.	$0.90	2.43
Truckee-Carson	Apr. 3, 1905	Pacific Portland Cement Co	Tolenas, Cal	1.50	....
Belle Fourche	Apr. 10, 1905	Western Portland Cement Co	Yankton, S. Dak	1.10	2.15
Do	May 19, 1905	Iola Portland Cement Co	Iola, Kans	1.00	....
Truckee-Carson	July 25, 1905	Pacific Portland Cement Co	Tolenas, Cal	1.50	....
Lower Yellowstone	July 31, 1905	Illinois Steel Co	South Chicago, Ill.	1.00	2.82
Huntley	Aug. 24, 1905	.....do	.....do	1.00	....
Do	Sept. 5, 1905	.....do	.....do	1.10	....
Shoshone	Sept. 26, 1905	.....do	.....do	1.30	....
Yuma	Sept. 30, 1905	Pacific Portland Cement Co	Tolenas, Cal	1.55	2.82
North Platte	Nov. 1, 1905	Portland Cement Co	Portland ($1.40), Denver, Colo.	1.59	2.20

Bids for cement.

Project.	Date.	Company.	Location of works.	Price at works.	Price at project
Truckee-Carson	Sept. 25, 1903	Spreckles Bros. Co	San Francisco, Cal.		$2.75
Do	do	Cowell Lime and Cement Co			3.50
Do	do	Grace & Co			3.44
Do	Nov. 7, 1903	Spreckles Bros. Co	San Francisco, Cal.		2.55
Do	July 8, 1903	Standard Portland Cement Co	Napa Junction, Cal.	$1.60	
Minidoka	Aug. 25, 1904	Portland Cement Co	Portland, Colo		3.26
Do	do	Kansas Portland Cement Co	Iola, Kans		3.37
Do	do	Utah Portland Cement Co	Salt Lake City, Utah.		[a] 2.95
Do	do	Atlas Portland Cement Co	New York City		3.71
Hondo	Jan. 10, 1905	Western Cement Selling Co.	Iola	[a] 2.83	2.95
Do	do	Atlas Portland Cement Co	New York City		3.39
Do	do	Portland Cement Co	Portland, Colo		2.95
North Platte	Mar. 16, 1905	Iola Portland Cement Co	Iola, Kans. (92 per cent).	.90	2.43
Do	do	Kansas Portland Cement Co	do	.90	2.99
Do	do	Portland Cement Co	Portland, Colo	1.10	2.53
Do	do	do	Salt Lake, Utah	1.75	
Truckee-Carson	Apr. 3, 1905	Pacific Portland Cement Co	Tolenas, Cal	1.50	
Do	do	Western Fuel Co	San Francisco, Cal.	1.70	
Belle Fourche	Apr. 10, 1905	Alpena Portland Cement Co	St. Paul, Minn		[c] 3.37
Do	do	Western Portland Cement Co.	Yankton, S. Dak.	1.10	2.15
Do	do	Fowler & Pay	Mankato, Minn	.95	2.78
Do	do	Kansas Portland Cement Co	Iola, Kans	1.25	3.07
Do	do	Illinois Steel Co	South Chicago, Ill.		[c] 3.32
Do	do	Wabash Portland Cement Co	Stron, Ind	1.10	[d] 3.17
Do	do	Portland Cement Co	Portland, Colo	.90	2.42
Do	May 19, 1905	Iola Portland Cement Co	Iola, Kans	1.00	
Truckee-Carson	July 25, 1905	Western Fuel Co		1.60	
Do	do	Pacific Portland Cement Co	Tolenas, Cal	1.50	
Do	do	Utah Portland Cement Co	Salt Lake City, Utah.	2.00	
Lower Yellowstone	July 31, 1905	Illinois Steel Co	South Chicago, Ill.	1.00	2.82
Do	do	Alpena Portland Cement Co	St. Paul, Minn	1.37	2.89
Do	do	Atlas Portland Cement Co	New York, N. Y.		2.97
Yuma	Aug. 4, 1905	California Cement Co	Colton, Cal		3.16
Do	Aug. 12, 1905	Portland Cement Co	Tolenas, Cal	1.50	2.76
Huntley	Aug. 24, 1905	Illinois Steel Co	South Chicago, Ill.	1.00	
Do	Sept. 5, 1905	do	do	1.10	
Shoshone	Sept. 26, 1905	do	do	1.30	
Do	do	Portland Cement Co	Portland, Colo	1.35	
Do	do	Alpena Cement Co	St. Paul, Minn	1.40	
Yuma	Sept. 30, 1905	Pacific Portland Cement Co	Tolenas, Cal	1.55	2.82
Do	do	Western Fuel Co	Napa Junction, Cal.	1.60	2.88
Do	do	Western States Portland Cement Co.	Independence, Kans.	1.25	2.96
Do	do	California Portland Cement Co.	Colton, Cal	2.45	3.07
North Platte	Nov. 13, 1905	Portland Cement Co	Portland, Colo	[b] 1.40	2.198
Do	do	Illinois Steel Co	South Chicago, Ill.	1.30	2.645
Do	do	Western States Cement Co	Jackson, Mich		3.00
Do	do	Sunderland Bros	Omaha, Nebr		3.25
Do	do	Wm. Parr & Co	Galveston, Tex		3.85

[a] At Denver. [b] Ideal. [c] Sacks. [d] Bulk.

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